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OBSERVATIONS
AND
EXPERIMENTS
For inveſtigating the
CHYMICAL HISTORY
OF THE
Tepid SPRINGS of BUXTON;

TOGETHER WITH

An Account of ſome newly-diſcovered, or little known Properties of Subſtances relating to ſeveral Branches of CHYMISTRY, and ANIMAL and VEGETABLE LIFE;

TO WHICH ARE PREFIXED,

A CHRONOLOGICAL RELATION OF THE USE OF BUXTON WATER FROM THE EARLIEST RECORDS TO THE PRESENT TIME, SKETCHES OF A HISTORY OF THE ATMOSPHERE OF THE PEAKE, AND OF THE EXTERNAL FORM AND INTERNAL STRUCTURE OF THE MOUNTAINOUS REGIONS OF DERBYSHIRE;

INTENDED FOR THE

Improvement of Natural SCIENCE and the Art of PHYSIC;

LEEDS INFIRMARY MEDICAL LIBRARY

In TWO VOLUMES.

VOL. I.

BY GEORGE PEARSON, M.D.

LONDON:
PRINTED FOR J. JOHNSON, ST. PAUL'S CHURCH-YARD.
MDCCLXXXIV.

Monendi utique ſunt Homines, et per Fortunas ſuas rogandi, atque obſecrandi, ut Animos ſubmittant, et Scientias in Mundo majore quærant: quinetiam de Philoſophia vel cogitationem abjiciant, vel modicos ſaltem, et tenues Fructus ex illa ſperent, uſque dum Hiſtoria Naturalis et Experimentalis diligens et probata, comparata ſit, et confecta.

LORD VERULAM in Novo Organo.

TO THE MOST NOBLE

WILLIAM DUKE OF DEVONSHIRE,

PROPRIETOR OF THE TEPID WATERS OF

BUXTON;

WHERE,

FOR THE CONVENIENCY OF THE PUBLIC,

HIS GRACE HAS MUNIFICENTLY PROVIDED

SUCH VERY HANDSOME AND AMPLE

ACCOMMODATION:

THESE OBSERVATIONS

AND EXPERIMENTS,

ARE VERY RESPECTFULLY INSCRIBED,

BY HIS GRACE's

DUTIFUL AND

OBEDIENT SERVANT,

THE AUTHOR.

PREFACE.

THE Occaſion of theſe Volumes of *Obſervations and Experiments*, that are now ſubmitted to the Judgment of the Public, was the Diſcovery of an Error in the Opinion univerſally and confidently entertained, concerning the Nature of a Kind of *Air*, or, more properly, of a *permanent Vapour*, that impregnates the tepid Waters of Buxton, on which their peculiar Efficacy in Diſeaſes was believed entirely, or principally, to depend.

Preſuming that Philoſophy and the Art of Phyſic would be benefited by the Demonſtration of this Miſtake, and by a Recital of the Facts which eſtabliſh a different Opinion, I intended to publiſh the Obſervations and Experiments which diſcovered the Properties of this permanent Vapour, along with the Inferences that naturally followed from them.

In executing this Deſign, I found that many of my Concluſions were rendered vague, or leſs extenſively uſeful, and that others could not be drawn, for want of a general chymical Hiſtory of this Spring-Water conſidered as an elementary Subſtance, and of the other Matters, beſides the above permanent Vapour, that might be contained therein. For without a Knowledge of the Qualities of all the ſimple Subſtances forming a compound Body, we cannot, upon many Occaſions, refer the Effects produced by it, or at leaſt we cannot aſcribe them, with any great Degree of Probability, to one or ſeveral of the component Parts of ſuch a Body, but muſt conſider them as the Conſequences of the whole in Conjunction.

I was, therefore, induced to attempt an Inveſtigation of the whole of the chymical Properties of Buxton-Water, and to collect the Facts already diſcovered upon this Subject. At the ſame Time, I examined attentively the Grounds on which theſe Spring-Waters were employed in Phyſic; and finding them to be vague or erroneous, I formed a Plan for eſtabliſhing the Uſe of this Article of the *Materia Medica* upon a more ſolid Foundation.

In Conſequence of theſe Reflections my original Plan was much enlarged, and I had now before me a wide and unexplored Field of Enquiry, a ſmall Part only of which I flattered myſelf with the Expectation of being able to inveſtigate, and even that Portion imperfectly; but I hoped my Labours therein, would render the Work which I at firſt intended much more uſeful, and make the Cultivation of this Ground leſs difficult for thoſe who might deſire to improve it hereafter.

My great Motive for undertaking this Work, was that of being ſerviceable to Mankind by labouring to contribute my Mite to the Advancement of Science, and the Improvement of the Art of Phyſic. I preſumed that this Purpoſe would in ſome Meaſure be ſerved, by making a ſmall Addition to the preſent Stock of natural Hiſtory; and I cannot imagine any juſt Reaſons why my Endeavours ſhould occaſion the leaſt Uneaſineſs in the Mind of any Perſon. I may diſcover the Miſtakes, without undervaluing the Judgments, of thoſe Philoſophers by whom they were committed. Conſidering the Fallacouſneſs and limited Power of the external Senſes, even when aided by the beſt contrived Experiments and the moſt excellent mechanical Inſtruments, it is very probable, many Errors and Miſtakes will in future be pointed out to have been committed in the Hiſtory now preſented to the Public. The Obſervations and Experiments here related, as the Reader will perceive, required merely Attention, Patience, and Reflection, and did not demand Sagacity, or Ingenuity; — the Inſtruction derived from them, was too obvious to eſcape the Notice of any Perſon of ordinary Penetration.

Leſt thoſe who are engaged in the Practice of Phyſic principally from lucrative Motives, ſhould be diſquieted by Phyſicians whoſe main Object is the further Inveſtigation of this Art; I ſhall obſerve, that profeſſional Emoluments are not inſeparable Accompaniments of Men who have made the moſt uſeful and important Enquiries in Nature for the Advancement of the Art of Healing; becauſe the higheſt Degree of this Kind of Merit does not obtain them, without concomitant Qualifications of a very different Nature from profeſſional

feſſional ones, and by thoſe Qualifications independent of uncommon profeſſional Merit the greateſt Honours and Emoluments have, frequently, been obtained. And here I cannot help obſerving, that I fear a principal Occaſion of the comparative Slowneſs of the Progreſs of Phyſic to that of the other Arts, and particularly the little Improvement of it ſince the Days of Hippocrates, notwithſtanding the Lights and Aids afforded by various Branches of natural Hiſtory and Philoſophy, has been, that the Profeſſors of this Art perceived that popular Reputation and lucrative Practice were not at all, or not ſpeedily to be obtained by mere Inveſtigations of Nature, without alſo beſtowing Time and Attention on Subjects foreign to the Art of Phyſic; therefore, from Motives of *Self-Preſervation*, the Deſire of *Gain*, or the Love of *public Diſtinction*, Phyſicians have oftentimes been induced to cultivate the Artifices of Inſinuation and Addreſs rather than the Field of Science :——

> " Declinat Curſus, Aurumque volubile tollit."

It may be proper to acquaint my Readers that the newly-diſcovered, or little known

Properties of Subſtances relating to ſeveral Branches of Chymiſtry, and animal and vegetable Life, contained in theſe Volumes, are either Facts that were accidentally diſcovered during my Search after different Objects, or they were introduced for the Purpoſe of illuſtrating particular Subjects of Enquiry. On this Account I have frequently been obliged to make Digreſſions from what the Reader will ſuppoſe the proper Subject of the Work, and which contain Matter that might have been omitted or related in an Appendix to theſe Volumes: as however I wiſhed to communicate my Obſervations and Experiments as nearly as poſſible in the Order in which they were made, I could not follow that Plan conſiſtently with the Order of the Narrative I propoſed.

In making my Obſervations, and deſcribing the Reſult of my Experiments, I have not been influenced by any preconceived Opinions or favourite *Hypotheſes*; therefore my Errors as an Hiſtorian muſt have ariſen from the Deception or Weakneſs of my external Senſes, and they may be detected and rectified by future Obſervers. If, on a Repetition of my

Experiments and Obſervations, it ſhall be found that I have deſcribed *Properties* which do not exiſt; or if any Part of this Work ſhall appear obſcure, it will afford me a high Degree of Satisfaction, to receive from any candid and ingenious Perſon a Communication of the Miſtakes that I have committed, and a Mention of the Paſſages which ſhall require Illuſtration.

I have endeavoured in the Courſe of this Work to mention thoſe different Obſervers and ſagacious Interpreters of Nature, whoſe Diſcoveries I have Occaſion to cite, in ſuch Terms as ſhall not give Offence; and I have to the beſt of my Knowledge quoted the original Authors of them; nor have I, that I know of, mentioned as my own, what is the Obſervation of any other Perſon, without acknowledging to whom I am beholden.

The firſt Section, containing a *Chronological Account of the Uſe of Buxton-Water*, is compoſed for the Sake of gratifying thoſe of my Readers who have Pleaſure in knowing paſt Events independent of other Conſiderations;

and becauſe ſuch a Relation may poſſibly aſſiſt in the Inveſtigation of more uſeful Knowledge, namely, that of the *chymical Properties* of the principal Subject of my Inquiry.

I am apprehenſive that a great Part of this Work which contains the Experiments on *permanent Vapours*, will appear ſomewhat unintelligible to many of my Readers. The mixing of different Solids, or different fluid Subſtances together; the meaſuring of Fluids; or the transferring a fluid Subſtance from one Veſſel into another, are Operations too familiar to need any Explanation; but permanent Vapours, or compreſſible and commonly inviſible Subſtances are ſo very rarely employed in the Practice of the Arts in common Life, that ſcarcely any Perſon, beſides certain Experimenters, comprehends the Manner in which the Operations now mentioned are performed on them, as well as on Fluids and Solids.

It would not be conſiſtent with the Plan of this Publication to deſcribe particularly the Manner of performing Experiments on *permanent Vapours*, together with the Principles of theſe Experiments. Therefore, for the right underſtanding of many Parts of theſe Volumes, I muſt refer thoſe Readers who are not converſant with the Subject of permanent Vapours, as Air, and other Subſtances in this Form, to peruſe attentively the *Introductions to Dr. Prieſtley*'s *five Volumes of Experiments and Obſervations on different Kinds of Air*, and Mr. *Cavallo*'s *Treatiſe on the Nature and Properties of Air, and other permanently elaſtic Fluids*; likewiſe the Explanation of the Plate in *A Treatiſe on the various Kinds of permanently elaſtic Fluids, or Gaſes*, 2d Edition, 1779; and the other Authors referred to whoſe Inſtruments I have employed. I ſhall only juſt obſerve, for the Sake of affording a general Idea to thoſe who want an Explanation of this Subject, that when a permanent Vapour is *transferred*, or *poured* from one Veſſel, as a Phial, Jar, or Beer-Glaſs, into another Veſſel, it muſt be conceived that two Veſſels ſtand inverted, *one* filled with, and placed inverted in a Veſſel of Quickſilver, with the Mouth below the Surface of this Fluid, if a Subſtance that readily combines with Water, as Gas, is to be transferred; or if it does not at all, or but in ſmall Quantity unite with Water, as Air or nitrous Gas, Water may be more conveniently employed than Quickſilver: the *other* Veſſel containing permanent Vapour may have any Quantity of the permanent Vapour it contains thrown into the Veſſel filled with Fluid, by turning it ſufficiently immerſed in Fluid into an upright Poſition and holding the Mouth of the other Veſſel, with or without a Funnel therein, over the Bubbles forced out by the Fluid taking the Place of the permanent Vapour, ſo that they ſhall riſe within the inverted Veſſel filled with Fluid: by which Means a Bulk of Fluid will be diſplaced in Proportion to the Bulk of permanent Vapour that riſes within it.

When a permanent Vapour is to be *meaſured*, the inverted Phial or Veſſel filled with Fluid previouſly found to contain a certain Bulk may be employed; and when filled with permanent Vapour it will contain a Bulk of this Subſtance equal to the Volume of Fluid; or, *Marks* may be made on the inverted Veſſel of Fluid, denoting that when filled as high as certain Marks it contains a certain Bulk of Fluid, and the permanent Vapour may be made to riſe within this Veſſel previouſly containing a Fluid, until the Fluid is expelled as low as the Marks.

Two or more permanent Vapours may be *mixt* together by transferring them in the Manner juſt deſcribed into the ſame inverted Veſſel.

By a little Practice it is quite as eaſy to *transfer* permanent Vapours from one Veſſel into another, to *mix* them together, and to *meaſure* them, as it is to perform the ſame Things with Fluids.

I have taken the Liberty of employing a few Terms that have been hitherto leſs frequently in Uſe than others ſignifying the ſame Things; becauſe I either find thoſe in more general Uſe are confeſſedly improper, and are even reckoned ſo by thoſe who have invented and employed them; or they have been adopted without Conſideration, and before the Nature of the Subſtances they were appropriated to expreſs were well underſtood. I flatter myſelf I ſhall give no Offence by this Procedure. As ſoon as I find the Public, for good Reaſons, diſapprove of the Terms here made uſe of, I ſhall upon any future Occaſion relinquiſh them.

OBSERVATIONS
AND
EXPERIMENTS,
For inveſtigating the
CHYMICAL HISTORY
OF THE
TEPID SPRINGS of BUXTON, &c.

PART I.

SECTION I.

A chronological Account of the Uſe of BUXTON-WATER, *for Pleaſure or Health, from the earlieſt Records to the preſent Time.*

AT BUXTON (*a*), a ſmall Town or Village in the Peake of Derbyſhire, there are tepid Springs, which, on account of their medicinal

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(*a*) The following are Conjectures concerning the Etymology of the Word Buxton, formerly written Buckſtone, or Buckſtones.

" It is not unlikely that the Stagges or Buckes wounded, would take Soyl ther, and there the Foſters of the Forreſt called it Buckſtand ; but in my Judgment the former Suppoſition is more likely ;" viz. that it derives its Name from *Buck*, the Name of the Owner of the Town.—See a Book, entitled, medicinal Qualities have been treated by differ-

ent

entitled, " The Benefit of the ancient Bathes of Buckſtones, which cureth moſt grievous Sickneſſes, never before publiſhed, compiled by *John Jones*, Phyſition, at the King's Mede, nigh Derby, Anno Salutis, 1572, London, 4to."

" The Etymology of Buxton, I take to be from *Boc*, Fagus, or *Bocca*, Caper, and ſtan, a Stone." See Mr. Pegge's Account of the Roman Roads through the Country of the Coritani, or County of Derby, 1779.

" The Name of Buxton, or Buckſtane, as perhaps it ſhould be more correctly written, according to the Truth of the Etymology, is however, but modern, in Compariſon of the Antiquity of the Place; for this can riſe no higher than the *Saxon* Age, neither do I find it occurring in any very old Author."—Mr. Pegge's Account, &c.

If theſe Baths were uſed by the Saxons as by the Name of *Batham Gate*, a Road leading to the Bath, ſo named by Way of Eminence, it ſhould ſeem they did, one may deduce the Name *Boc, Coxit*, q. d. the warm Stones or Rocks, or warm Springs among the Rocks; alſo from *Boc*, or *Buc*, a Beech-Tree, if we were certain this Kind of Tree ever grew there. *Skinner* derives the Name of Buxton from Beocce, Bocce, and tun, a Town. The Name of this Town ſeems to occur under the Name of Bectune in Doomſday-Book.

For theſe laſt obſervations I am indebted to the learned R. Gough, Eſq; and I ſhall add, that it is very certain the Beech-Tree will grow at Buxton, becauſe ſeveral of this Species were planted ſome Years ago near the Hall at Buxton, and are now in a flouriſhing State.

I have conjectured that Buxton is derived from Bock-Stein, or Stein-Bock, which is a German Word, and ſignifies that Animal, which the Engliſh call the Stein-Buck, or the wild Goat; the French, Bouquetin, formerly Bouc eſtain, or Boucſtein, i. e. Bouc de Rocher; and the Latins, *Ibex*.

Whether it be probable, that this Animal might formerly inhabit ſuch a Climate as the Peake of Derbyſhire, I leave the Reader to determine for himſelf. To aſſiſt his Judgment, I ſhall quote the following Part of the Natural Hiſtory of the Wild Goat, from Mr. *Buffon*.—" Le Bouquetin & le Chamois, que je regarde, l'un comme la Tige mâle, & l'autre comme la Tige femelle de l'eſpece des Chèvres, ne ſe trouvent, ainſi que le Mouflon, qui eſt la ſouche des Brebis, que dans les Déſerts, & ſurtout dans les Lieux eſcarpés des plus hautes Montagnes; les Alpes, les Pyréneés, les Montagnes de la Grèce & celles des Iles de l'Archipel ſont preſque leſs ſeuls Endroits où l'on trouve le Bouquetin & le Chamois: quoique tous deux craignent la Chaleur, & n'habitent que la Region des Neiges & des Glaces, ils craignent auſſi la Rigueur du Froid exceſſif; l'Eté ils demeurent au Nord de leurs Montagnes, l'Hiver ils cherchent la Face du Midi, & deſcendent des Sommets juſques dans les Vallons: ni l'un ni l'autre ne peuvent ſe ſoutenir ſur les Glaces unies, &c. p. 14. Hiſtoire Naturelle Générale & Particulière, &c. Tome IV. à Paris, 8vo, 1772."

I beg Leave to obſerve, that although in Summer this Animal might not find in the Peake a Climate agreeable to its Nature, yet in the Winter Seaſon it would be there ſufficiently cold, and as the warm Weather approached, it might travel along the Ridge called the Anglo-Appenine, Northward; where, either in England or Scotland, the Air might be of a Temperature ſuitable to the Conſtitution of this Creature. There are, indeed, no Animals of this Sort that I have heard of in Derbyſhire, but there might be formerly, before the Foreſts were cut down, as well as other Species of Animals that now no longer exiſt there: for we are told by *Camden* (ſee his Britannia by *Gibſon*) that there were Wolves anciently in the North of Derbyſhire, " for the Hunting of which, Lands were held at *Wormhill*, or Worme-hill, from whence thoſe Perſons were called Wolveſhunt, as is manifeſt from the Records of the Tower," and Wormhill had its Name from Wolf-haunt.

ent Author's (*b*), and mentioned in various Kinds of hiſtorical Writings, for more than two hundred Years paſt (*c*).

Ruins, Remains, and Veſtiges of Art (*d*), which were allowed to be of Roman Workmanſhip,

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(*b*) The Benefit of the ancient Bathes of Buckſtones, &c. by John Jones, 1572.

Several Obſervations relating to Buxton Wells, MSS.— This Book is in the Liſt of Writings relating to Derbyſhire, given by Gibſon in his Edition of Camden's *Britannia.*

Liſter de Thermis & Fontibus medicatis Angliæ, p. 36.

Short's natural, experimental, and medicinal Hiſtory of the Mineral Waters of Buxton, and other warm Waters in the Peak of Derbyſhire, 4to.

Hunter on the Nature and Virtues of Buxton-Waters, 1761.

Experiments and Obſervations on Buxton-Waters, &c. by Dr. Percival, Vol. 62. Phil. Tranſ.

(*c*) Camden's Britannia, firſt publiſhed about 1607.

Leland's Itinerary, Vol. 7. P. I. p. 65.

The Theatre of Great Britain, &c. by John Speed, 1676.

Childrey's Britannia Baconica, p. 112.

Leigh's natural and artificial Wonders of the Peak, 1700.

Salmon's New Survey.

De Mirabilibus Pecci, Carmen Thomæ Hobbes.

Wonders of the Peak, by Cotton, in Engliſh Verſe.

Mr. Bray's Tour.

A great Number of other Books publiſhed within theſe laſt 30 Years.

(*d*) " That theſe Baths were anciently known the Cart Road, or *Roman* Cauſey, called *Bathgate*, which continues ſeven Miles from hence to the little Village *Burgh*, does plainly teſtify; and much more plainly the Roman Wall cemented with red Roman Plaiſter, cloſe by Saint Anne's Well, where ſhip, that have been diſcovered at different Times in the Neighbourhood, and adjoining to theſe celebrated Waters, are the Records from which it is collected, that the Romans made Uſe of the tepid Waters of Buxton as Baths. Independently

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where are the Ruins of the ancient Bath." See Biſhop Gibſon's Edition of Camden's *Britannia*.

Stukeley's Itinerarium curioſum, p. 52, 53. and Salmon's Survey of England, Vol. II. p. 543.

"This ancient Roman Wall about Saint Anne's Well was, together with its Baſon, totally razed in 1709, when Sir Thomas Delves, of Cheſhire, erected the preſent beautiful Arch over that noble tepid Fountain."—Short's Works, before cited, p. 23.

"Sir Thomas Delves, of Cheſhire, in Memory of a Cure he received here, cauſed an Arch to be erected, in digging the Foundation for which they came to the Remains of a ſolid and magnificent Structure of Roman Workmanſhip; and in other Places in the Neighbourhood very capacious leaden Ciſterns, and a Variety of other Utenſils, which evidently appear to be alſo of Roman Workmanſhip, have been diſcovered.—See Campbell's Political Survey of Great-Britain, 1774, Vol. I. p. 99.

"Here too (viz. thirty-three Yards north-eaſt from the Bath at Buxton ariſes Saint Anne's Well,) the Romans had erected their noble Works, and here was the ancient Chapel dedicated to Saint Anne, by which Buxton was preſerved in Reputation."—See Leeland and Jones, cited in Campbell's Political Survey.

"*Saint Anne's Well* formerly roſe up into a Stone Baſin, ſhut up within an ancient Roman Brick Wall a Yard ſquare within, and a Yard high on three Sides, till Sir Thomas Delves built the preſent Arch over it, which is twelve Feet

long,

pendently of theſe Teſtimonies, it is extremely improbable, that for the Space of near five Centuries, during which Period England was provinciated to a Nation with whom warm Bathing was the moſt uſual Luxury, the celebrated Fountains

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long, and twelve Feet broad, ſet round with Stone Seats on the Inſide; it has a ſtrong Iron Bar running acroſs its Eaſt End, or Entry, inſtead of a Wall, to keep the Arch firm. In the Middle of this Dome the Water ſprings up into the Middle of a Stone Baſon two Feet ſquare above, but three Feet wide below on the Side next the Bridge from the ſhelving Stone laid over on the North Side above the main Spring. The leſſer Spring riſes up in the weſt End of this Baſon, it bubbles up conſtantly all over. This Well is twenty-four Yards north of the outer Bath."—Short, p. 44.

" The moſt extenſive and the moſt remarkable of the *Roman* Remains, in the County of *Derby*, are, I preſume, the two Roads, which that People formed there; whereof the former and the greater, extended in a Manner the whole Length of the County, from South-weſt to North-eaſt: and the other, which I call the leſs, croſſed a Part of the *Peak*, to wit, from Buxton, where the Bath is, to the Station or City at *Brough*, near *Hope*."—Mr. Pegge's Account of the leſſer *Roman Road* in the County of *Derby*, called the *Bath-way*.

" Buxton is undoubtedly a very ancient Place, the warm Spring there being diſcovered very early, and no Doubt in the *Roman* Times. This I infer, not ſo much from the vulgar Name above-mentioned, which can be no older than the *Saxon* Æra, as from the Exiſtence of a *Roman* Road pointing directly to it, and the *Saxons* having that Reaſon for denominating this artificial Road the Baþon-ȝate."—Mr. Pegge's Account, &c.

" I

tains of Buxton ſhould not be employed; the Heat of which, although, moſt probably, not ſo great as that of their artificial Baths, was capable of producing agreeable Senſations upon Immerſion, and to the Employment of which, they would

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" I do not find any Traces of the Road in Queſtion (Bath-way) to the North or North-eaſt of Brough, whence it may be reaſonable to conclude, that as it extended no farther that Way, it was merely intended for a commodious Communication between this Place and *Buxton* Bath. *Brough* was certainly once a Place of Conſequence, and probably very populous. But now from hence to Buxton the Road is very capable of being traced, as we found by Experience, for the Materials of which the Stratum is compoſed are totally different from the natural Ground on each Side. The Stratum, or Cauſey, is not much raiſed any where, (indeed there was but little Occaſion for that, the Ground being in general hard and ſound) but is the moſt ſo at the firſt ſetting out; however, in ſeveral Places upon Tids-well-moor, you may diſtinguiſh the Sides of it for many Yards together, ſo as to form a good Judgment of its Breadth, which we found to be ſeven or eight Yards."—Mr. Pegge's Account.

" That the Water was of great Reputation in the darkeſt diſtant Times is undeniable, from the Chapel here dedicated to Saint Anne, whoſe Foundation was likewiſe diſcovered, and a large Piece of its Wall dug up in driving the foreſaid Level, and no Doubt ſeveral other valuable Pieces of Antiquity might have been there then, had there been any Perſons of Judgment and Curioſity."—Short, on Mineral Waters.

Speed deſcribes Saint Anne's Well as " incloſed with four flat Stones, called Saint Anne's," of which he gives a Drawing as well as of the Hall.

" Mr.

would be further invited by the cryſtalline Appearance, want of Colour, Taſte, and Smell of the Water.

Although we have no Records to ſhew, that theſe Waters were employed for the Purpoſe of Health or Pleaſure, previouſly to the Conqueſt of Part of Britain by the Romans, or for ten or eleven Centuries after it was abandoned by that People (*e*); yet we are not to conclude, that they were not made uſe of on both theſe Accounts.

Such

Mr. Watſon lately diſcovered a Roman Station near Buxton.

About four Years ago, in digging the Foundation for the new Building now erecting called the *Creſcent*, the Remains apparently of two Baths were found, one had a Plaiſter Floor, with ſome Bottles in it, ſuppoſed to be Roman Bottles, and was nearly of the Figure of the preſent Baths, but not ſo large; the other was ſmaller, and had a Wall of Stone.

Either at the Time of Sir Thomas Delves's Arch being erected, or a ſhort Time after, was made the Plantation of Fir-Trees, called the *Grove*, which was lately deſtroyed to make Room for the Foundation of the *Creſcent*.

(*e*) Perhaps the Chapel dedicated to *Saint Anne* is a Proof of the Waters being in Repute during the Period here ſpoken of.

" It is obvious, that the Bath at Buxton was in greater Requeſt under the *Roman* Emperors, than ever it was in the later Ages; the *Monkiſh* Hiſtorians, as it would ſeem, knowing little or nothing of it, unleſs you will ſuppoſe it to be included in certain general Expreſſions relative to the medicinal warm Waters of the whole Iſland, as where Bede ſays," &c. —See Mr. Pegge's Account of the *Bath Way*.

" Mr.

Such were the State of the Arts, and the Occupations of Mankind in thoſe Ages, that we can ſcarcely expect any Relation of the Effects of theſe Springs, had they been in Requeſt.

In 1572, either upon the very Spot where the preſent Building, called *The Hall*, has ſince been erected, or very near it, ſtood the principal Building for the Reception of Viſitors, which was at that Time reckoned a fine Manſion: and there was then alſo a *Bath* that appears to have been ſupplied by the ſame Springs, in the ſame Place

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"Mr. William Lambarde (Topogr. Dict.), and Dr. John Jones (Benefit of Buckſtone's Bath), who both flouriſhed in Queen Elizabeth's Time, are the firſt, I think, of our printed Authors that mention Buxton and the Bath there; for what may be thought very ſtrange, John Leland never once mentions it in his Itinerary, as if it was a Place but little known, or of ſmall Conſequence in his Time. Jones however teſtifies, that the Place, for many Years before his Time, had been frequented by Thouſands, for the Purpoſe of bathing; but Mr. Lambarde inſinuates, that what Character the Place then obtained, was aſcribed as much to the miraculous Aſſiſtance of St. Anne, the Patroneſs of the Place, as to any ſalutary Virtue in the Waters; whence it appears, that though the Place was then much frequented, it was only ranked amongſt the *Holy Wells*. Dr. Jones ſays much the ſame. However this Gentleman contributes vaſtly, I apprehend, to raiſe the Credit of the Place by his Book; for from that Time, to carry this Account no lower, the Waters of Buxton came into a high Degree of Vogue, both for drinking and bathing."—Mr. Pegge's Account of the *Bath Way*.

as at this Day (*f*). This *Hotel*, or *Hall-Houſe*, and *Bath*, are the ſame as thoſe ſpoken of by Camden, about thirty or forty Years after this Date (*g*).

One hundred and twenty Years ago, or about 1670, this Building was deſtroyed, and a new Edifice

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(*f*) "Joining to the chief Spring, between the River and the Bath, is a very goodly Houſe, four-ſquare, four Stories high, ſo well compact with Houſes of Office beneath, and above, and round about, with a great Chamber, and other goodly Lodging, to the Number of Thirty, that it is and will be a Beauty to behold, and very notable for the Right Honourable and Worſhipful that ſhall repair thither, as alſo for others; yea, and the Poor ſhall have Lodgings and Beds hard by for their Uſes only. The Baths alſo ſo bravely beautified with Seats round about, and defended from the ambient Air, and Chimnies for Fire to air your Garments in the Bath Side, and other Neceſſaries moſt decent." See Jones's Benefit of Buckſtone's Bath.

(*g*) "At the Riſe of the River Wye there are nine Springs of hot Water, called at preſent Buxton Wells, which being found by Experience to be very good for the Stomach, the Nerves, and the whole Body, the Moſt Honourable George Earl of Shrewſbury adorned them with Buildings, upon which they began to be frequented by great Numbers of the Nobility and Gentry. About this Time the unfortunate and heroic Princeſs Mary Queen of Scots took her Farewel of Buxton in this Diſtich, being Cæſar's Verſes upon Feltria, applied to Buxton;

Buxtona, quæ calidæ celebrabere Nomine Lymphæ,
Forte mihi poſthac non adeunda, vale.——"

Camden's Britannia, p. 142.

The

Edifice erected by William the third Earl of Devonſhire. This Manſion, with, probably, various Alterations and Additions, is the principal Hotel at Buxton, now called *The Hall.* It is probable, that the Bath remained in exactly the ſame Situation as before, and where it is at this Day, becauſe the main Spring therein ariſes from a Fiſſure in the Stratum of Lime-Stone; but as the Houſe has been ſaid to be between the Baths and River, and as the Bath is now in the back Part of the Houſe, it would ſeem, that there had been ſome Alteration in the Spot upon which the Building was erected by the above Earl of Devonſhire. Among other ſubſequent Alterations, appears to have been the Addition of two other *Baths*, one for the Uſe of *Female Bathers*, and the other for the *Poor*, adjoining to the *old Bath*, now appropriated for the Men, called *The Gentleman's Bath.*

A Number of other excellent Houſes for the Reception of Viſitors have been erected within theſe laſt 50 Years, and they have of late been increaſed almoſt annually. At preſent there is a ſuperb and ſpacious Pile building, from its Figure,

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The above Princeſs Mary was many Years in the Cuſtody of the Earl of Shrewſbury at Hardwick. This Nobleman and his Wife, the celebrated *Elizabeth Counteſs of Shrewſbury*, frequently viſited Buxton. Their royal Priſoner, probably, accompanied them in their Excurſions to this Place, and during one of theſe Viſits ſhe wrote the above valedictory Lines.

gure, called *the Creſcent*, which is intended to afford various Sorts of Accommodation.

The Arch and Well erected after the Demolition of the Roman Wall and Baſin (ſee Note (*d*), Page 4), were about four Years ago demoliſhed to make Room for the Foundation of the Creſcent. The Water had been hitherto conducted from ſmall ſubterraneous Streams of a tepid Spring, for ſome Diſtance, into this Well; ſo that moſt probably the Well antiently was not exactly on the Spot where Sir Thomas Delves's Well was made. After the Deſtruction of the Well a ſecond Time, for the Purpoſe juſt mentioned, the Water was conveyed in a ſmall Grit-Stone Channel, 46 Feet long, in a different Direction, viz. about 46 Feet South Eaſt, into a neat ſquare Baſin of white Marble, incloſed within a Temple in the Style of Grecian Architecture: where it is drank at this Time, without having ſuffered any Alteration in its Properties, and with ſome ſuperior Advantages, as we ſhall ſhew hereafter.

From the increaſed and ſtill increaſing Buildings for the Accommodation of Viſitors on account of Health, or in Purſuit of Pleaſure, it is rendered probable, and by the numbering thoſe who reſort to Buxton it has been proved, that theſe Waters have been much more frequented ſince the firſt conſiderable Hôtel erected by the Earl of Shrewſbury, and afterwards rebuilt by the Earl of Devonſhire, and that the Uſe of them is extending. Among other Cauſes of the frequent Uſe of theſe Springs, muſt be reckoned the increaſing Luxury of the Nation; the more eaſy Communication by Means of various Turnpike Roads leading on all Sides to and from Buxton; and the Faſhion of the Times to viſit what are called *Watering Places* during the Summer Seaſon, eſpecially in Countries that abound with delightful and uncommon Scenes of Nature.

The tepid Fountains of Buxton are reſorted to now-a-days, almoſt entirely for the Pupoſe of removing or relieving Diſorders; whereas, in the Time of the Roman Empire in Britain, they were probably more in Requeſt for Pleaſure than Health.

SECTION II.

Grounds on which Buxton-Water has been hitherto applied in the Cure of Diſeaſes.

THE moſt ancient Grounds on which Phyſicians have employed Buxton-Water, from the Period when the Earl of Shrewſbury provided the firſt convenient Habitation for ſick People more than two hundred Years ago to the preſent Time, have been,

1. *Traditional Knowledge, or Rumours of its Effects in the Cure of Diſeaſes.*

As the Caſes in which Buxton-Water has been uſed on this Ground were rarely diſcriminated; as its Effects were only related in the moſt vague and inaccurate Manner, and as the Caſes related were, for the moſt Part, imaginary, this Principle of Practice has been hitherto little better than Conjecture or random Experiment.

2. *Obſervations,* it has been alledged, have been made *of the Effects of theſe Waters in Diſeaſes* by ſeveral Obſervers, and recorded in the Writings of Doctor Jones, Liſter, and Allen. The Plan mentioned by Doctor Jones of regiſtering the Effects of the Water on Patients who frequented Buxton was, no Doubt, the very beſt Foundation of Practice. But as the Effects of this Water have been related inaccurately, and very incompleatly, and as the Hiſtories of the *Caſes* have not at the ſame Time been given, the Obſervations and Concluſions recited are not of more Uſe than the former Principle in Practice.

3. Phyſicians have attempted to found their Judgment of the Uſe of Buxton-Water in Diſeaſes on *the Effects of bathing in common Spring-Water,* ſuppoſed to have been already inveſtigated. But as we have only a very imperfect and inaccurate Hiſtory of the Effects of *cold* and *warm Bathing,* or of Immerſion in Water, heated to about 50° and 96°; and as the Temperature of

Buxton-Water is very different from either of theſe Baths, the Effects of it are not deducible from a Knowledge of thoſe of *cold* and *warm Bathing*, were we even in Poſſeſſion of that Knowledge, and were the Effects of the *tepid Springs* of *Buxton* the ſame as thoſe ordinary Spring-Water of the ſame Temperature; therefore it follows, that Practice grounded upon this Foundation muſt have been erroneous.

4. From the earlieſt Records to the preſent Time we find, that Practitioners have been directed in the Application of theſe Waters by the Knowledge they poſſeſſed of their ſimple Properties, and of the Kind and Quantity of Subſtances they conceived them to contain; that is, *by their Knowledge of the Phyſical and Chymical Hiſtory of this Subſtance.*

A Phyſician inſtructed in this Knowledge, is no doubt able to form a Judgment, on many Occaſions, with tolerable Certainty, concerning the Effects of Subſtances applied in Diſeaſes; and very generally, by Means of this Knowledge, he is aided in his Practice and Inveſtigations.

But a great Part of the Phyſico-Chymical Hiſtory of Buxton-Water, till within even a few Years ago, was not of ſuch Properties as had been obſerved by the external Senſes, but of Properties created by the Imagination, and ſuch as a ſubſequent Acquaintance with phyſical Laws, and with the Qualities of Subſtances, independently of Demonſtration by particular Evidences, prove to be abſurd or fictitious (*h*).

Phyſicians have reaſoned, and do at preſent reaſon, not only upon the Effects of imaginary impregnating Subſtances and Qualities of theſe Waters, but account for their Effects in Diſeaſes

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(*h*) *Allen* ſuppoſes this Water to contain Lead, Iron, and Sulphur; but *Short* obſerves, that *Jones* "is much righter where he thinks the Water is too pure, delicious, and fine, for any ſuch Principles as Lead, Copper, or Allum; and contents himſelf with an *Impalbable Sulphur*."—*Short*, p. 59.

Liſter ſays, theſe Springs "are very clear, and ſcarcely depoſit any Clay or Earth, and though they are not of the *atramentous Kind*, yet they plainly taſte of Iron."—*Short*, p. 74. cites Liſter *de Aq. Medicat. Ang. Exercit. prior*, p. 35.

Leigh affirms, that "theſe Waters are ſulphureous and ſaline, yet not fœtid, very palatable, becauſe the Sulphur of theſe Waters is not united to Vitriol."

Again, "Where ſulphureous Waters tinge Copper Colour, it is from the Addition of vitriolic Salt, as Harrigate: Other ſulphureous Waters tinge Silver of a golden or yellowiſh Colour, as in the Bath in Somerſetſhire, there is a great Proportion of Sulphur and little Vitriol: But if they tinge none at all, it is all Sulphur and no Vitriol, as Buxton."—*Short*, p. 48. cites Leigh, p. 31. Book I.

"Since this Water waſhes ſo many Ingredients, abounding with Sulphur, and we find that even groſs Sulphur, by the Mediation of Limeſtone, communicates ſome of its Parts to Water, and alſo as there is conſtantly ſuch a viſible ſulphureous *Halitus* as upon the Surface of the Water, then it is reaſonable to conclude, that this Water, whilſt warm, is impregnated with ſulphureous Steams or Vapour, as one Part of its mineral Spirit."—*Short*, p. 55.

on the Removal of Cauſes that are the Creatures of Fancy, and the Exiſtence of which are often inconſiſtent with the known Laws of Nature.

But were this Hiſtory authenticated by proper Evidence, it would be ſo very incompleat, that practical Deductions made from it muſt have been liable to very many Exceptions, and have depended much upon the Part of this Hiſtory not inveſtigated; therefore it would do little Service to the Phyſician, although it might be uſeful to the Philoſopher.

Of late Years, a Part of the chymical Hiſtory of the tepid Waters of Buxton, we have Reaſon to believe, has been better inveſtigated; but it was not accompanied with the Proofs on which it was eſtabliſhed, was too imperfect, and Practitioners were not thereby enabled to make any uſeful Inferences, or place a practical Dependence on ſuch as might have been drawn.

5. Some of the Profeſſors of the healing Art, have had for their Guide *the Event of ſuch Caſes as have fallen under their own Obſervation.* But the Experience of the Events of Diſorders of any one Perſon, directed ſolely to this particular Object, without other Aids, would not probably be ſufficient to eſtabliſh any Principles of Practice, that would enable us to produce Effects with any great Degree of Certainty; it would, however, contribute to that End. The few Examples

therefore that any Phyſician has had in the ordinary Courſe of his Practice may accidentally apply in particular Caſes, but can afford no general Rules of Direction; and conſequently, this Ground has been of extremely little Uſe in Practice.

6. There are many very learned modern Phyſicians, who being unable to diſcover any efficient chymical Properties of Buxton Water from the Hiſtory now in the Poſſeſſion of the Public, are inclined to account for the Power of this Subſtance in removing or relieving diſeaſed States, from *its Qualities as ſimple Water*; and certain *concomitant Agents* that have an acknowledged Influence on human Health, to which the Habit is neceſſarily expoſed during the Uſe of this Water. Theſe Agents, which neceſſarily accompany the Uſe of Buxton Waters, are the Exerciſe of travelling to theſe Springs; probably a Difference in the Qualities of the Atmoſphere; an Alteration in the Exerciſe of the mental Functions (*i*), ariſing from a Suſpenſion of

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(*i*) Porrò Varium Vitæ Genus maximè in Uſu fuiſſe apud Antiquos ad longe Salubriterque Vivendum, vel ex ipſo diſcere licet Seneca meo & Celſo. Nihil enim peſtilentius eſt, nihil ad Salutem pernicioſius in Hominibus negotioſis, aulicis, Curis publicis, vel privatis tota Die fatigatis, Studio deditis, quam in eadem Intentione Laboreque continue detinere Mentem nullam eidem Laxitatem debitamque Hilaritatem concedendo.—*Baglivi.* This Author cites the Authority of the Attention to domeſtic Concerns, and other Buſineſs of Life, Scenes of Amuſement, various Kinds of Society, a Change in the Face of the ſurrounding Objects of Nature, and the Confidence, or at leaſt Hope, that is cheriſhed of a Reſtoration of Health by Means of the Water; the uſual Change of Food, Drink, Hours of Sleep and Watching; and the Exerciſe of the Body by riding, walking, &c.

But different Spring Waters of Celebrity are not alike in their Effects on Diſeaſes, and the above concomitant Agents are all pretty nearly the ſame at different Watering-Places; at leaſt the Difference of theſe Agents at different Places, is not ſufficient to account for the peculiar Effects of each Spaw, if we except the Qualities of the Atmoſphere, in which there may be a conſiderable Difference, and which we conceive to be

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rity of Seneca for the good Effects of the Varium Vitæ Genus, of ſometimes the wiſeſt Men being engaged in childiſh Amuſements; Socrates played with Children, and Cato drank Wine, by Way of Relaxation from mental Labours; concluding, "Negotioſis itaque Hominibus & Studio deditis, ſingulis Diebus, debita Hilaritas Animorumque Laxitas juxta Senecæ præceptum concedenda: quod ſi monitum hoc poſthabeant, floccique faciant Mille Morborum Generibus hac Solum de Cauſa obnoxii erunt; & unde quæſo tot Affectiones hypochondriacæ, ſcorbuticæ, Mortes repentinæ aliique innumeri Morbi his Diebus in Negotioſis Hominibus oriuntur, quam à negata Animis Curarum onere preſſis debita, commodaque Laxitate?"

the moſt powerful of all theſe Agents. It ſtill then remains, upon this Principle of a Difference in the Atmoſphere, to account for the peculiar Efficacy of medicinal Waters; and this I apprehend muſt be ſought for, if not in the Water alone, at leaſt in the Water accompanied with the Influence of the Atmoſphere of the Region of Buxton.

In general I apprehend, that theſe accompanying Agents have not been ſufficiently diſtinguiſhed from each other, nor their Effects, together and ſeparately examined; nor a Difference of Application conſequently made in different Caſes. The *diſtinguiſhing Properties of the Sky*, far from being duly inveſtigated, have ſcarcely been thought of, excepting, perhaps, in a vague Manner, as to Temperature. Therefore, until a full and accurate Hiſtory be made of the diſtinguiſhing Qualities of the Atmoſphere of the Peake of Derbyſhire, at and near the Source of Buxton Waters, the Influence of theſe Springs on human Conſtitutions cannot be determined; and conſequently, admitting this Principle to be founded in Truth, it's Application cannot be directed with Preciſion, or even on probable Grounds.

From the preceding Survey of the various Grounds on which Buxton Water has been uſed in Diſeaſes, it appears, that Obſervations have not yet determined the particular Effects of Buxton Water in different diſeaſed States of the Body.

But if we do not know whether any, or what Effects have been produced by this tepid Water, the Queſtion will naturally be propoſed, how the continued, and even increaſed Uſe of it for ſeveral hundred Years, can be accounted for?

Various Motives may be conceived, to have induced a Number of diſeaſed Perſons to make the *firſt Trials* of Buxton Water; ſuch as vague Experiment, by thoſe who had found no Relief from Means already employed; the natural Propenſity of the human Mind to make Trial in Diſeaſes of any *new* Subſtance, or of a Subſtance poſſeſſing *extraordinary* Qualities, &c. A Number of ſick People being thus induced to make Trial of this Water, if as great a Number, or nearly as great, found Relief and experienced Cures in Conſequence of its Uſe, as after any other Means already known, it may be reaſonably inferred, that this Spring would in future be as frequently employed as thoſe Means; provided, however, that it had equal Advantages on other Accounts.

The Rumour of the good Effects, may be conceived to have firſt induced ſick People to make repeated Trials in Caſes ſuppoſed to be ſimilar to thoſe relieved; and in which it was, from reaſoning on erroneous Principles, ſuppoſed to be helpful. As Mankind have continued the Uſe of this Water for a Period of ſeveral hundred Years,

and

and as the Frequency of its Application hath increaſed, as the Means neceſſary to, or of promoting its Employment have increaſed, it may be fairly inferred, that the Cure and Relief of Diſeaſes have, at leaſt, in ſome of the numerous Caſes which have followed the Uſe of Buxton Water, been effected by this Subſtance. For although the Reſtoration of Health, and Relief in Diſeaſes, have been known to follow, and, as is deducible from the Properties of the human Frame, may happen, in almoſt every Diſeaſe, *after the Application of any Subſtance whatever*; and although the Diſpoſition of the human Mind inclines us to apply, as Medicines, any *new Subſtances*, or any Thing poſſeſt of *extraordinary Properties*; yet, if the ſalutary Effects, on Repetition, be diſcovered to enſue as frequently without their Application, or after the Application of almoſt any other Subſtance, ſuch Subſtances, after a few Trials fall into Diſuſe; provided, however, that other Subſtances have, by the Teſt of repeated Experiments, been found to produce the ſalutary Effects expected from the Subſtance of which the Trials had been made without ſalutary Conſequences following. But if no ſuch Subſtances be known, any *Thing* whatever may, from the Nature of the human Paſſions, and from profeſſional Motives, continue in Uſe, and that in Frequency, in Proportion to its Agreeableneſs and Conveniency of Application. Conſidering, however, the preſent very improved State of Natural Hiſtory, it is ſcarcely probable, that a Subſtance entirely *non-efficient*, will continue ſo long in Practice as a Period of ſeveral ſucceſſive Centuries.—Such a long and uniform Uſe can only be accounted for, on the Suppoſition of its being productive of ſalutary Effects, as frequently as other Means known, although the Manner, and particular Diſeaſes in which theſe Effects are operated, be not diſcriminated.

In this Manner we account for the continued Uſe of Buxton Water for ſeveral ſucceſſive Centuries; and if we do not demonſtrate, it is hereby rendered extremely probable, that this Subſtance poſſeſſes the Power of curing and relieving Diſeaſes. But ſuch has hitherto been the Negligence of Mankind, that we neither know the particular diſeaſed States it is capable of removing or amending, nor on what its Power of producing theſe Effects depends.

The Conſequences of this State of Ignorance are,

1. That this Subſtance is liable to be applied in Caſes where it has no Effect, or is variouſly hurtful.

2. That probably it cannot be applied, even where it is ſalutary, in ſo efficacious a Manner as it otherwiſe might be.

3. That its Uſe cannot be ſo extenſive as it muſt naturally be, were the Properties of the Water, or the Impregnations underſtood, in which its medicinal Qualities reſide.

SECTION III.

A PLAN *for the Inveſtigation of the medicinal Properties of* BUXTON WATER.

THE Method of inveſtigating the peculiar Effects of Buxton Water in particular diſeaſed States, and in what its ſeveral Powers of producing theſe Effects reſide, appears to be,

Firſt, To enquire into *the Properties of the Atmoſphere of the Peake:* For this, as we have before obſerved, is the only peculiar *efficient Agent*, or *Means*, capable of operating any conſiderable Changes on the human Frame in Diſeaſes, *accompanying* the Uſe of Buxton Water; the other concomitant Agents being common to the Uſe of medicinal Waters in general.

This Enquiry is neceſſary, in order to diſcriminate the Effects of this tepid Water, from thoſe of other Means of amending or reſtoring Health, to the Influence of which, the human Syſtem is neceſſarily expoſed during the Application of Buxton Water.

Secondly, *To inveſtigate the Properties of Buxton Water*; which are comprehended under the following Heads:

I. ITS CHYMICAL HISTORY;

1. As a ſimple or elementary Subſtance.
2. As impregnated with extraneous Matter.

II. THE HISTORY OF ITS EFFECTS ON LIVING SUBSTANCES;

1. On Vegetables,
———————— in Health.
———————— Diſeaſe.
2. On Animals,
———————— in healthy States.
———————— diſeaſed States.

Beſides the Utility of the preceding Hiſtories, for the Purpoſes of natural Science, and Arts in general, they are each of them of ſpecial Uſe for the Attainment of the Object of our Enquiry. Being inſtructed by the *chymical Hiſtory* in the principal Properties of this Water, and in the Sort and Proportion of Subſtances it contains; among various other practical Inferences, we

1. May frequently form a Judgment, if not with Certainty, at leaſt with Probability, of its Effects on Health and Diſeaſe; provided the Properties and Subſtances be ſuch as thoſe

Properties and Subſtances with whoſe Effects we are acquainted. Or, if the Properties and Subſtances be ſuch whoſe Effects are not already known; this Circumſtance ſuggeſts efficient Cauſes, or at leaſt probable or poſſible efficient Cauſes, of Effects before or without it unaccountable, and alſo new Sources of Knowledge and Enquiry.

2. If we know the efficient Properties or Subſtances contained in Waters, we are enabled to direct their Application, upon many Occaſions, with greater Certainty of Effect. Suppoſe, for Inſtance, the peculiar Efficacy of a Water to reſide in its Temperature, or in a Subſtance that is a Vapour, in the Heat of the Water and that of the Atmoſphere, and is ſo mixt with it, that it readily eſcapes ſpontaneouſly upon Expoſure to the open Air: This ſuggeſts, that this Water muſt be of the ſame Heat as at the Spring-Head, when employed at a Diſtance from it, in the firſt Caſe; and in the latter, that Attention ſhould be paid to apply the Water, under ſuch Circumſtances, as that the Vapour it contains be not previouſly detached.

3. If different Properties and Subſtances in the Water have, ſeparately, and variouſly conjoined, diſtinct Effects, according to the diſeaſed States in which they are applied; this Knowledge may enable us to apply the efficacious Qualities and Subſtances with much greater Effect, by mak-

ing a Separation of the efficient from the non-efficient Parts and Properties; and by applying the former in a larger Portion, or Doſe, than can be exhibited by Means of the Water.

4. If the efficacious Subſtances be procurable by Art, or found elſewhere in Nature, although we may not exactly imitate the natural Compound, I mean the Water, we may have it in our Power at any Place, and upon any Occaſion, to procure and adminiſter thoſe Parts which are efficacious; where, either the Water could not be at all, or not without Difficulty obtained. The Pyrmont Water, and Sea Water, are the moſt frequently compoſed by Art, and the artificial are apparently in all Reſpects equal to the natural Compounds. The Manner of imitating Waters, that owe their Efficacy to Gas (*k*), hath been ſhewn ſome Time ago, by *Venel*, *Shaw*, and ſome others; and a more complete, accurate, and eaſy Method has been diſcovered of late Years by Dr. *Prieſtley*.

The Chymical Hiſtory of Water, therefore, in Part, ſupplies the Place of the Hiſtory of its Effects in diſeaſed States, may be more readily attained, and alſo renders this Hiſtory much more uſeful and complete.

The Hiſtory of the Effects of this Water on living Vegetables, in their different States of

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(*k*) By Gas, I mean that permanent Vapour, which is frequently called fixed Air or fixable Air, and calcareous Gas.

Health and Diſeaſe, may advance us in the Acquiſition of the Knowledge we aim at, as the End of our Labours: For ſuch is the Analogy between Animal and Vegetable Life, that certain Principles may frequently be applicable to both. Such Deductions, however, ſhould not be received and applied in Practice without Caution, and conſidering, that they are liable to Differences and Exceptions.

Farther, the Effects of Subſtances on Vegetables, upon ſome Occaſions, are their diſtinguiſhing Properties, and furniſh Lights in the Courſe of other Inveſtigations.

The Mind, being in Poſſeſſion of the Knowledge of the *Effects produced by the tepid Water of Buxton on various Claſſes* of *Animals in Health*, is thereby enabled to make many practical Inferences. For the Cure or Relief of Diſeaſes, is oftentimes effected by Changes operated on certain Functions *not* affected by the Diſeaſe to be removed or palliated.

Secondly, The Effects produced, in Conſequence of which Diſeaſes are cured or relieved, are frequently of the ſame Kind in Health and Diſeaſe, only differing, perhaps, in Degree. In either of theſe Caſes, being acquainted with the Effects of Buxton Water on healthy Animals, we deduce the Caſes in which this or any other Agent is medicinal or hurtful.

But there are very many Caſes in which Diſeaſes are changed for Health, or variouſly altered, by Agents that do not produce Effects on healthy Functions, of the ſame Kind as thoſe by which they cure or palliate Diſeaſes. For Inſtance, the Changes produced by the Peruvian Bark in healthy Bodies, are not thoſe by which it cures intermittent Fevers. The ſame may be ſaid of Quickſilver, in the Cure of the Lues Venerea; of Opium in the Tetanos; of Antimony in continued Fevers, &c.

We ſee then the Extent of the Application of this Subſtance in Practice, on the Ground of the foregoing Hiſtory; that it ſupplies the Place of the Hiſtory of the Effects of Buxton Water on *diſeaſed States*, only imperfectly; but being much more readily obtained than this Hiſtory, in the Order of Subjects to be inveſtigated, it ſhould have the Precedency, for the Sake of preſent Uſe: It alſo throws Light on the other Hiſtories, by aſcertaining the Kind and Differences of Things, and points out on what the peculiar Efficacy, in Diſeaſes, of compound Subſtances, depends.

The moſt intereſting of all Knowledge on this Subject is, that of the *Effects of Buxton Water on all the various Claſſes of Animals in diſeaſed States.*

Being poſſeſt of a compleat and accurate Hiſtory of the Effects of this tepid Water in all the various Diſeaſes incident to the human Frame, we ſhall be able to diſtinguiſh the Caſes in which it is helpful, hurtful, or inefficacious; and therefore to apply it ſo, as to produce the Effects required with Certainty and Preciſion.

The other Hiſtories enable us to produce Effects in a few Diſeaſes with tolerable Certainty; in ſome others on the Grounds of Probability; in very many Caſes, indeed, they beſtow not any Power of commanding Events; but they all accelerate the Acquiſition of the Knowledge of the Effects operated by this Subſtance in Diſeaſes.

The Attainment of this Knowledge is a Work of immenſe Labour, and the Reſult of a long Space of Time. The Induſtry of any one Perſon directed wholly or principally thereto, for the uſual Period of human Life, would be able to inveſtigate only a ſmall Part of this Hiſtory, and that Part imperfectly. It is a work that requires the co-operating Labours of many Obſervers, and the ſucceſſive Obſervations of Numbers, at different Times, to render this Hiſtory tolerably compleat. The Extenſiveneſs of this Hiſtory, however, ſhould not deter any one from exerting his Endeavours towards the Attainment of it; becauſe, it is only by the united Labours of many Perſons that it can be obtained; and every one who contributes but a ſmall Portion towards it, although that Portion of itſelf ſhould be of little Uſe, is a Benefactor to Mankind. And this Hiſtory ought to be conſidered as the moſt important of the Hiſtories propoſed, becauſe it is by this alone that we can become thorough Maſters of the Powers of Buxton Water for the Purpoſes of Phyſic.

Conſidering, however, the Length of Time and Labour requiſite to cultivate this Hiſtory, ſo as to render it uſeful to any conſiderable Extent, it may not be improper to recommend firſt, the Acquiſition of the other Hiſtories; becauſe they are more readily attained, and alſo expedite the Attainment of this Hiſtory: Although it muſt be remembered, they can ſupply the Place thereof only partially; and human Induſtry muſt not ceaſe till it is obtained, if a compleat Knowledge of the Powers of Buxton Water be deſired.

This Hiſtory of the Effects of Subſtances on other Animals in a State of Diſeaſe beſides Man, for the Uſe of Phyſic, has ſcarcely been thought of; but where attainable, it may be of conſiderable Uſe, by the Inferences that may be drawn from it with Reſpect to the Practice of Medicine, and the Lights derived from it for the general Promotion of Science, and the Inveſtigation of the other Hiſtories.

SECTION IV.

PLAN *of the preſent Work.*

HAVING preſented to the Reader a View of the preſent State of Knowledge of Buxton Waters, and of the Application of that Knowledge, and alſo the Foundations on which we conceive the Uſe of this Subſtance might be better eſtabliſhed, we ſhall proceed to lay before the Public a ſmall Part of two of the preceding Hiſtories, although imperfectly executed, with the View of contributing to the Attainment of the grand End propoſed, the Knowledge of the Powers of Buxton Water in relieving and curing Diſorders, namely the

Hiſtory of the PECULIAR QUALITIES *of the* ATMOSPHERE *of the Peake of Derbyſhire*; and the

Hiſtory of the CHYMICAL QUALITIES *of the* TEPID WATERS *of Buxton.*

From theſe Hiſtories we ſhall make ſuch practical Deductions as appear naturally to ariſe from them, and which may eſtabliſh the Application of Buxton Water in Diſeaſes, upon a better Foundation than that on which it now ſtands.

We hope too, that theſe Obſervations may contribute towards the Poſſeſſion of even more important Knowledge than that of any particular Art—that of the *Cauſes of Things*; becauſe this empowers the human Mind to produce with Certainty Numbers of Effects; the Knowledge of Arts, only particular Effects, and theſe upon ſome Occaſions. This Knowledge of Cauſes of Things, is what conſtitutes the Empire of the human Mind over Nature; in Conſequence of which, we are enabled to explain natural Phænomena, and to direct at Will, natural Subſtances to the Uſes, Conveniencies, and Delight of common Life. Hence the naturally calamitous Situation of Man, is rendered as ſafe and happy as is competent to his natural Condition.

In order to inveſtigate the Properties of Buxton Water, neceſſary or aſſiſting Lights may be borrowed from a Contemplation of the *internal Structure and Contents* of the Region of the Earth from whence it ſprings. And to aſſiſt us in this Enquiry, as well as that into the Properties of the Atmoſphere, we ſhall deſcribe *the external Form and Appearance* of the mountainous Land of Derbyſhire.

The Atmoſphere of the Peake, and the external and internal Structure of the Earth of this Region being naturally connected, they ſhall be the Subject of the three ſubſequent Sections.

SECTION V.

Of the external Form of the mountainous Land of Derbyſhire.

BUXTON is ſituated on the Weſtern Side of the North Part of the County of Derby, in a Tract of elevated, uneven, and hilly *Moor-Land*, called therefore the *High-Peake*, or the *Peake-Hundred.*

The *Peake* is about fourteen or ſixteen Miles broad from the South-weſt to the North-eaſt Side; its whole Length from the North-weſt to the South-eaſt may be twenty Miles, and it is ſuppoſed to contain one fourth Part of the whole County, or 170,000 Acres.

This Region of high Land is the Southern Extremity of the Ridge or Chain of Mountains and Hills, that extends from the Cheviot Hills in Scotland nearly through the Middle of the Iſland, and terminates in the North Part of Derbyſhire. As this Range of eminent Land runs through the Middle of the North of England, as the Appennine does through Italy, it has been called *the Engliſh Appennine* (*l*).

The

(*l*) "The north Part of the County (Derbyſhire) riſes gently into ſmall Hills which begin here, and like the Appennine in Italy, run through the Middle of England in one continued Ridge, riſing higher and higher as far as Scotland, The Britiſh Appennine may be reckoned, for the Sake of forming a general Conception of it, from fifteen to twenty Miles broad. Near Scotland it is much broader, and as the Iſland to the North of Derbyſhire contracts itſelf conſiderably in Breadth, this Tract of high Land bears no ſmall Proportion to the Breadth of the North Part of England.

The whole Length of this Ridge of Land appears to be about an hundred and twenty to an hundred and forty Miles.

The Elevation of different Parts of the Anglo-Appennine above the Sea in the German Ocean to the Eaſt, and in the Iriſh Channel to the Weſt, and above the Lands interpoſed between it and the Seas to the Eaſt and Weſt, and alſo above the Land to the South of the Peake, cannot be ſtated for want of Geometrical or Barometrical Obſervations aſcertaining this Fact; but a tolerable

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land, under ſeveral Names. For here they are called Moorland, after this *Peake*, then *Blackſtone Edge*, annon *Craven*, and laſt of all *Cheviot*, when they branch out into Horns." *Camden*'s Britannia.

"The large Country of the Brigantes runs out narrower and narrower, and is cut in the Middle (as Italy is with the Appennine) by a continued Ridge of Mountains, and theſe ſeparate the Counties into which it is divided. For under theſe Mountains to the Eaſt and the German Ocean lie Yorkſhire and the Biſhopric of Durham, and to the Weſt, Lancaſhire, Weſtmoreland, and Cumberland." *Camden*'s Britannia.

rable Judgment may be formed of this Matter from the *Riſe*, *Manner of flowing*, and *Courſe of Rivers*; from the *apparent Elevation of Land*; from the *Climate*, *Soil*, *State of Vegetation*, &c. (*m*).

All the Rivers between the North of Derbyſhire and Scotland have their Origin in the *Engliſh Appennine*, and flow either Eaſtward to the German Ocean, or Weſtward to the Iriſh Sea; but at the Termination of this high Ridge in the North of Derbyſhire, they not only run to the Eaſt and Weſt, but a pretty conſiderable River, the *Derwent*, has here its Origin, and paſſes from the North of Derbyſhire directly to the South of the ſame County (receiving in its Courſe the *Wye*, and other Rivulets that have their Origin in the moſt Northern Parts of the County of Derby), where it falls into the Trent. Moreover the *Dove*, and ſeveral ſmall Rivers flow from, or nearly from, the North of Derbyſhire, and run Southward through or near the County of Derby to join the Trent in the South of Derbyſhire.

(*m*) The Height of ſome of theſe Mountains is as follows: *Pendle Hill*, *Pennygant*, and *Ingleboro*, have been eſtimated at 600 to 750 Yards above the Plane of the Vales between them. *Helwellin* and *Skidda* are, according to a Plan of Mr. *Smeaton*'s, elevated 1000 Yards above the intermediate Valley. Phil. Tranſ. Vol. LXV. P. II. p. 498.

Axedge, a large Mountain a few Miles from Buxton, as I am informed, is about 2100 Feet higher than *Derby*, and 1100 Feet above the Vale in which is *Buxton-Hall*.

In Yorkſhire there is an apparent Exception to this Direction of the Rivers above-mentioned; for there are ſeveral Rivers or Rivulets which riſe principally in the Northern Part of this Country between the Sea, and the great Ridge of high Land already ſpoken of, that run directly South, and Southward to join the *Humber*.

The above-related general Source of Rivers and their ſubſequent Courſes, denote the ſuperior Elevation of the Land in the Middle of this Part of England, where they riſe, to that of the Countries between it and the Sea; and that this ſuperior Elevation terminates in the North Part of Derbyſhire.

The Southern Courſe of ſome Waters in Yorkſhire above-mentioned will be underſtood, by obſerving, that there is a Kind of inferior Ridge of high Land which goes off nearly at right Angles from the great Ridge, and extends over the North of the County of York to *Whitby* and *Scarborough*.

The obvious Aſcent or Riſing of Land, which is in many Parts conſiderable and ſudden, experienced in travelling into the North Part of Derbyſhire from the Southern Parts of the ſame County, from Yorkſhire on the Eaſt Side, and from Cheſhire on the Weſt, is an *ocular Proof* that the Peake Hundred is conſiderably more elevated Land than that of the adjoining Countries.

The general external Appearance of this Region, viewed from the Summits of the Hills is, when the Atmoſphere is tolerably tranſparent, a more or leſs extenſive Proſpect of woodleſs (*n*) or naked Moor-Land that is either hilly, or has an undulatory Appearance reſembling the Form of the Waves of the Sea, and is for the moſt Part without, or with but few, Tokens of Inhabitants.

This Tract of Country is interſected in various Parts by Vales, *Ravines*, and Clefts among Rocks. Among the Vales is eſpecially that extenſive, and frequently fertile and beautiful Vale along which the *Derwent* winds it Courſe. Sometimes the Vallies are deep, broad, and fertile, without Cliffs or any romantic Appearances; at other Times they have Rocks on each Side, of various Magnitudes, Shapes, and Appearances, forming high and ſtupendous Precipices, ſome of which are as if cut ſmooth; others are rough, craggy, angular, and frightfully impendent: Sometimes

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(*n*) Not very long ago, this Region was covered with Foreſt Trees, at which Time it was inhabited by Wolves, Deer, and Goats. The Wood of this Country has been cut down, and conſumed principally in ſmelting the Lead Ore, and uſed for Fuel.

" Stags Horns have been found buried deep below the Surface of the Ground, of a conſiderable Size. The Skeleton of a Man was found at the ſame Time. The Interment of this Man and a Stag, were ſuppoſed to have been occaſioned by their falling into a Chaſm, or wide Cleft, in very early Times, which was afterwards filled up."—See Mr. Gale's Letter, May 19, 1744.

there are Rocks of the ſame Kind on the oppoſite Sides of a *Ravine*, correſponding in Height and Appearance; ſo that if they were brought into Contact, they would cloſe the Chaſm or Cleft entirely, without the Stratum on one Side of the Chaſm cloſed up being higher than that of the other. At other Times the Rocks on one Side are much higher than thoſe of the other, and the Direction of the Stratum of one Side is different from that of the other.

The Vales and *Ravines* are commonly watered by the Rivers *Wye* and *Derwent*, as well as by ſeveral ſmall Rivulets, but in ſome Parts they are dry; and I believe, they ſometimes have the Windings and Angles reſembling thoſe formed by Rivers in their Courſe; at others, they are without any regular Windings or Angles.

The Land upon the Hills is, in general, uninclosed, and produces little elſe but Heath (*o*), if we except a few cultivated Spots adjoining to the humble Habitations of the Shepherds of the Peake. Large ſhapeleſs Ledges or Blocks of

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(*o*) The Soil of this Region has a moſt remarkably antiſeptic Quality. We have, apparently, a well authenticated Inſtance of two human Bodies, buried a Yard deep in moiſt Soil of Peat-Moſs, which were not at all putrified after 28 Years and 9 Months; but which became putrid, as animal Bodies uſually do, after they were interred in common Earth, in Hope Church.—See Phil. Tranſ. No. 434.

Stone lie in many Parts upon the Surface of the Ground, as if caſually ſcattered there, in all imaginable Diſorder (*p*).

In the Vales Nature is oftentimes very agreeable to the Eye of the Beholder; for here there are Marks of Fertility of Soil, of Culture, and of Inhabitants. Here is produced Plenty of Graſs, and ſometimes Grain, but in general the Land is employed for Paſturage, and it is well ſupplied with Water by the Rivers and Rivulets that paſs through it.

> "Non liquidi gregibus Fontes, non Gramina deſunt,"
> VIRG.

The Vales are adorned by a Variety of Foreſt Trees and Shrubs, which, being intermixed with

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(*p*) "At the South End of Stanton Moor, cloſe to the Village of Birchover, is a very ſingular Maſs of large Rocks, called *Roultor*, *Rowter*, or *Roo-Tor*; whence Rowter means a moving Rock, ſince in the provincial Dialect, they will ſay, a Thing *roos* backward and forward, &c. Theſe Rocks ſtand on the Top of a Hill, commanding an extenſive View over the Moor, and ſeems to have been a Place much frequented by the Druids.

By the Number of druidical Remains on Stanton Moor, we may reaſonably ſuppoſe this Place to have been inhabited by the Druids. Here are Temples, Caves, Rock Baſons, rocking Stones, gorſed daus, Rock Idols, and Cairns. Their ſacred Groves have long ſince given Way to Cultivation; but their more durable Monuments have ſtood the Ravages of Time, and remain as Helps to illuſtrate their Hiſtory."——Hayman Rooke's, Eſq; Account of ſome Druidical Remains on Stanton and Huſtle Moor, in the Peake, Derbyſhire, 1780.

Rocks and Precipices, produce many romanticly grand and picturefque Scenes.

There are ſome remarkably large Grottos, or Caverns, which are popularly known, ſuch as that at Caſtleton, and one near Buxton: And alſo a Hole, or Chaſm, called *Elden-Hole*, of a very great Depth, which leads to a conſiderable ſubterraneous Cavern. This Hole has been occaſioned by ſome natural Operation, as a Current of Water (*q*). The whole Anglo-Appenine abounds with Caves, Chaſms, and deep Holes, (See *Tour to the Caves.*) Many of the Hills compoſing this Ridge of Land, appear to contain large Cavities, which have no Apertures by which they communicate with the Surface of the Earth; but which have been accidentally diſcovered by Miners, in ſinking Shafts for the Purpoſe of finding Ores. Near the Summit of the Hill, on the Weſt Side of the Vale of Matlock Bath, ſituated nearly Weſt from Matlock new Bath, is a Shaft about twenty-four Yards deep, which was made by ſome Miners, who were in Purſuit of Lead Ore. This Shaft leads to a ſubterraneous Cavern called *Cumberland-Mine*. The Extent of this Cavity, from North to South, I imagine, is at leaſt half a Mile. The Paſſage down the Shaft is, firſt through ſeveral Yards of the firſt Toad-

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(*q*) See a Deſcription of Elden-Hole, Phil. Tranſ. Vol. LXI. p. 250.

Stone, and through Part of the ſecond Lime-Stone; in this ſecond Lime-Stone is the Cavern I am deſcribing. It is of very various Dimenſions in different Parts, being from the Size that is juſt ſufficient to admit a Man to creep through it, to the Height of twenty, and Width of fifteen Yards. Upon the Floor appear ſcattered large Maſſes of Lime-Stone; its Sides and Roof are variouſly fiſſured; many of the Fiſſures are filled up with *Cawk*, *rhomboidal Spar*, *pyramidal Spar*, *Kebble*, *Clay*, and *Tuff-Stone*; alſo ſometimes with a ſmall Quantity of *Galena Plumbi*, or common Lead Ore of this Country. It is covered, in many Places, with *calcareous Earth cryſtalized* into various Shapes, which make a very pleaſing Appearance. Theſe Cryſtals are *Dog-Tooth Spar*, *Stalactites*, ſmall *cubic Cryſtals*, *white opaque ſpherical Cryſtals*, and a moſt delicate Cryſtal which, from its Whiteneſs, the Figure of it, and its reſembling exactly Snow, is called *Snow-Foſſil*. This laſt Form of cryſtalized Lime-Stone, is ſaid to be peculiar to this Cavern; and the Value of this Cavern entirely ariſes from its furniſhing Specimens of this Subſtance for Cabinets, and *Water-Icicle*, for poliſhing and making various Trinkets. The Difficulty of deſcending into this Cavern has, probably, occaſioned it to be ſeldom viſited; but as it is capable of affording Entertainment, by the Novelty, Variety, and frequently by the Beauty of its Appearance, it would undoubtedly be often noticed by inquiſitive Travellers, were the Deſcent into it more eaſy.

Moſt of the Springs in this Cavern, I ſhould have ſaid, are petrifying; and were of the Temperature of 49°, when the Air of the Cave was 52°, and the external Air 56°, in the Month of September 1783.

SECTION VI.

Of the internal Structure and Subſtances of the mountainous Land of Derbyſhire.

THE Number of Shafts that have been ſunk, and Holes made in the Earth, for the Purpoſe of procuring Metals, as well as for Fuel, Stone, and Water; and likewiſe the ſteep Rocks of the Vales and *Ravines*; and the natural ſubterraneous Paſſages or Caves, have afforded an Opportunity of obſerving, that the external Part of the interior Subſtance of the Earth, conſiſts of diſtinct Beds or Strata of different Kinds of Matter, diſpoſed in an orderly Manner, and not of a Heap of Subſtances thrown irregularly together.

Our Knowledge of the Structure and component Parts of the Earth, in the Moor-Land of Derbyſhire, extends to the perpendicular Depth of about two hundred and fifty Yards below the Surface of the Ground, reckoning from the Top of the Mountains; and by Obſervations and Reaſoning we can, with great Probability, infer what is its Structure at preſent, or what it has been originally, to the Depth of about five hundred Yards.

The principal Beds of which the Earth is compoſed, are from twenty to one hundred and twenty Yards in Thickneſs; they are all placed parallel, or nearly ſo, to each other, but in various Situations with Regard to the Horizon: Sometimes the Set of Beds, to the Depth with which we are acquainted, being placed parallel to, or in a Plane with the Horizon, but commonly inclined to it, forming therewith Angles of twenty-five Degrees or upwards.

The Beds of which the Earth conſiſts, to the Depth with which we are acquainted, are diſtinguiſhed from each other by the Species of Matter of which they conſiſt, which is of four Kinds, viz. *Grit-Stone*, a Subſtance readily converted into Glaſs by Heat and Mixture; *Shale*, an argillaceous Sort of Earth; *Lime-Stone*, or calcareous Earth, a Compound of Gas and Quick-Lime; and *Toad-Stone*, otherwiſe called *Channel* and *Cat-Dirt*, which, by ſome, is conſidered to be *Lava*, like that of Iceland or Veſuvius in its Appearance and in its chymical Qualities, as far as hath been inveſtigated; by others it is called Argillaceous Earth.

Toad-Stone is a blackiſh Subſtance, very hard, ſcratches Glaſs, but does not ſtrike Fire with Steel; has Bladder-Holes like the *Scoria* of Metals or Iceland Lava, or at leaſt of Clay hardened by the Volcano in Iceland; breaks alike in all Directions; and contains within it no animal or vegetable Bodies, or Impreſſions. Its ſpecific Gravity is nearly that of Veſuvian Lava; and it is ſo compact in its Bed, as to intercept the paſſing of Water from its upper Surface to the ſubjacent Stratum. When fuſed it gives Glaſs of the ſame Kind as melted *Veſuvian Lava*; and melts under the Blow-Pipe, with and without Tartar, to a black Slag. According to the Analyſis lately made, it is compoſed principally of Silicious Earth, with a large Proportion of Clay and Calx of Iron, and a ſmaller Quantity of calcareous Earth (*r*). It is variable in its Thickneſs in

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(*r*) Phil. Tranſ. Vol. LXXII. p. 327. Art. xx.—“ An Analyſis of two mineral Subſtances, viz. the Rowley-Rag-Stone and the Toad-Stone, by William Withering, M. D.”

Toad-Stone, when fuſed, appears to reſemble ſome of the Species of Lava.

Rowley-Rag, when fuſed, appears to reſemble Scotch Baſaltes.

One hundred Parts of Toad-Stone contain,

Silicious Earth	—	$63 \frac{5}{10}$
Calciform Iron	—	16
Calcareous Earth	—	$7 \frac{5}{10}$
Earth of Alum	—	$14 \frac{8}{10}$
		$101 \frac{8}{10}$

“ Nullam

the ſame Bed; and this Property makes an Exception to the Beds that compoſe the Earth of the Thickneſs with which we are acquainted, being all parallel to each other. This Subſtance is in Thickneſs from one to ſix hundred Feet, and even of a greater Thickneſs than yet cut through; and, conſidered as a Part of the natural Structure of the Earth in this Region, is ſometimes wanting. Fiſſures in the Stratum ſubjacent to the Toad-Stone Bed, are often filled up by this Subſtance. It has no Fiſſures or Veins, correſponding to thoſe of the incumbent and ſubjacent Strata.

Acids without Heat, and in their ordinary State, have no Effect upon this Subſtance.

"Nullam examinavi Argillam quæ non magnam fovet Silicis Quantitatem, plerumque ultra dimidium."—Bergman. Sciagraphia Regni Mineralis, p. 81.

I have lately ſeen Specimens of Scoria of Lead, Toad-Stone, and either Lava or Clay hardened, from Iceland, which could not be diſtinguiſhed, by their external Appearance, from each other.

Mr. Ferber (See his Oryctographie von Derbyſhire) calls Toad-Stone an Argillaceous Stone.

The common People who work in the Mines in Derbyſhire, conſider Toad-Stone to be Clay in an indurated State.

I have ſeen, a few Days ago, Specimens of the Stone, compoſing the Summit of the Rock of the Giant's Cauſeway, in Ireland, which reſembled exactly the Derbyſhire Toad-Stone; excepting, that the Bladder-holes of the latter were filled with calcareous Spar, thoſe of the former contained Fluor.

Air ſoon renders it ſoft, and converts it into a vegetable Mould, which is ſaid by ſome to be a Property of Veſuvian Lava and other Slags, as inſtanced in the Decay and Converſion into Earth of old Heaps of Slags from Iron Furnaces; but others will not admit this Change of Slags and Veſuvian Lava to be founded in Fact.

Beds of Earth are formed of the Matter rejected by Volcanos.—When a Volcano overflows, the Surface of the Earth is overſpread with liquid Fire to the Extent of many Miles around the Chimney of the ſubterraneous Fire; and in cooling, it forms horizontal or inclined Beds, which, in their Poſition are ſimilar to thoſe formed by Depoſitions from Water; but they are otherwiſe very different from thoſe Depoſitions. 1. They are not of an equal Thickneſs. 2. They contain Matter that has been evidently calcined, vitrified, or melted. 3. They do not extend to a very conſiderable Diſtance (*s*).

A Stone from Scotland, which ſome call *Lava*, others *Granite*, is uſed for paving the Streets of London; and *Lava* from volcanic Hills in Heſs is employed for building Houſes, repairing Roads, &c. as I obſerved a few Years ago at Heſſe Caſſel.

(*s*) We are indebted, principally, to Mr. Whitehurſt, (See his Enquiry into the original State of the Earth.) And alſo to the Biſhop of Llandaff (See his *Chymical Eſſays*), for this Account of the Properties of Toad-Stone.

The above-mentioned Strata are diſpoſed upon each other according to a certain Rule or Order; for *Grit-Stone* is always, when preſent, *incumbent on Shale*; and *Shale,* when preſent, is *placed upon Lime-Stone*; and *this laſt Stratum is incumbent on Toad-Stone,* if preſent.

And, as there are very generally ſeveral Beds of Toad-Stone and Lime-Stone, the firſt Bed of Toad-Stone is ſuperincumbent on a ſecond Bed of Lime-Stone; and this ſecond Stratum of Lime-Stone on a ſecond Bed of Toad-Stone; then is placed under this laſt Stratum a third Stratum of Lime-Stone; and under this laſt Bed lies a third Stratum of Toad-Stone, which is incumbent on a fourth Bed of Lime-Stone. Of the fourth Stratum of Lime-Stone we have very little Knowledge, and that only in a few Places; and as it has never been cut through, we are altogether ignorant of the Beds and Subſtances of which the ſubjacent Earth is compoſed.

The Strata of Grit-Stone and Shale are frequently wanting, and oftentimes alſo the firſt Bed of Lime-Stone; and, when this happens, I believe likewiſe the firſt Toad-Stone Stratum is always miſſing, and then the ſecond Bed of Lime-Stone becomes the uppermoſt Stratum.

Interpoſed between the Lime-Stone and Toad-Stone Strata are ſmaller Beds from four to ſix Feet thick: They are of *Clay,* of a lightiſh blue Colour, with a Tinge of Green, and contain *Pyrites* and *Spar* in *Nodules.*

The Springs flowing from theſe Clays, have been found to be warm, according to the Obſervation of the late Mr. George Tiſſington of Winſter. I was told, that a few Years ago, at Matlock, in digging for the Purpoſe of laying the Foundation of ſome Building, the Workmen came to this Kind of blue Clay, between the ſecond Lime-Stone and ſecond Toad-Stone; and from this blue Clay, warm Springs flowed. It is ſaid, that all the warm Springs ariſe from the blue Clay between the ſecond Lime-Stone and ſecond Toad-Stone; for that all the Springs flowing from between the firſt Lime-Stone and firſt Toad-Stone are cold.

There is one Inſtance of this Clay being burnt one Foot thick, by the accidental Inflammation of a Bed of Pit-coal.

The above deſcribed Strata, it is thought, were the original and naturally conſtituent Parts of the *Cruſt of the Earth* in this Part of Derbyſhire; but ſome of them have been, by ſome Means or other, removed.

Beſides theſe original Strata, there are ſome Beds which are looked upon as not eſſential to the natural Conſtitution of the Earth, and are therefore called *accidental ones.* Theſe are principally Beds of Clay in various States of Induration, and of inflammable Matter, diſpoſed alternately upon each other; both which are incumbent always on Grit-Stone, Shale, Lime-Stone,

&c. They are called Beds of *Argillaceous Stone or Clay Beds*, and *Coal.*

Theſe *Argillaceous Beds* contain a Variety of *vegetable* Impreſſions, but *no animal Remains* whatever; and Iron-Stone, with ſuch a Quantity of Calx of this Metal, as to be named Iron Ore. I lately, however, ſaw the Impreſſion of Cockles moſt diſtinctly, in a Piece of Coal found near Wakefield.

Theſe Beds of Argillaceous Matter, and Coal, principally exiſt in the lower *Moor-Lands,* and more *Southern* Part of Derbyſhire.

There are alſo, incumbent upon the above Strata, in various Parts of the Country, in the Vales eſpecially, and alſo in the High-Lands, *Beds* of *Sand* and *Gravel,* which are rounded Grit or Lime-Stone, according to the Stratum on which they are incumbent; and have the ſame Appearance as Stones depoſited by Rivers or the Sea, and rounded by Attrition; like thoſe upon the Sea-Shores, or compoſing the Beds of Rivers. Moreover, we frequently meet with other Subſtances, forming the *higheſt Beds,* or Parts of Beds, incumbent on the large and general Strata; ſuch as *Marle, Creta fuſca,* or *Rotten-Stone,* &c. In the Beds of *Marle,* which are ſometimes deep, we find great Quantities of *vitriolic Selenites,* known better by the Name of *Gyps, Plaſter,* or *Alabaſter*; but theſe

Subſtances are only found in the Southern Part of Derbyſhire.

The Beds of ſtony Matter, formed by the Depoſition of calcareous Earth upon animal, vegetable, and foſſil Subſtances, called *Petrifactions*, are found, eſpecially at Matlock; being the Productions of the tepid Springs of that Place (*t*), and other petrifying Waters.

Tuff-Stone is not, I believe, a ſeparate Bed; or, if a diſtinct Bed, it is contained in the general Strata of the Peake. It is calcareous Earth in a ſoft State, and of a porous Texture.

It muſt not be conceived, that the above *vitreſcible* or *ſcilicious Earth*, called *Grit-Stone*, *argillaceous Earth* or *Shale*, and *calcareous Earth*, are all uniformly of the ſame Appearance, as to Colour, Texture, &c. or unmixed with other Subſtances.

The *Toad-Stone* Stratum, is a tolerably uniform Subſtance, and does not contain any different Maſſes of Matter, that I know of, excepting ſome inconſiderable Cavities that are filled up with calcareous Earth, which is there cryſtalized. Theſe Cavities, or ſmall Holes, thus filled up, are called, when empty, *Bladder-Holes*, and give it a ſpeckled Appearance. By Expoſure to the Weather, I am told, the Bladder-Holes filled

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(*t*) See a particular Deſcription of the petrified Stratum, formed by the tepid Waters of Matlock, by Dr. Dobſon, Phil. Tranſ. Vol. LXIV. Part I. p. 124. and many Years before this laſt Paper, Phil. Tranſ. No. 456.

with Spar, are frequently robbed of this Subſtance, and left empty, in which State they are frequently found.

The *Sand-Stone* Strata are alſo tolerably uniform, and contains only quartz Pebbles; which are, I believe, ſometimes in Fiſſures that are filled up with them, variegate them, and ſeem to have the ſame Relation to the Strata of Sand-Stone, that Spar has to Lime-Stone.

Shale, called alſo *Shiver*, an argillaceous Earth, contains *Iron-Stone* in Nodules, and ſometimes, according to Mr. Whitehurſt, ſtratified. Many Springs iſſuing from this Stratum contain Iron; as that of the Bridge at Buxton, another at Quarndon, one beyond Matlock Bridge, towards Chatſworth, and alſo one at Heage, which contains a very great Quantity of vitriol of Iron. In this Stratum the Miners frequently meet with the *Fire-Damp*, or *Oil of Metals* (*u*); alſo with a Subſtance of the Conſiſtence of *Molaſſes*, which is highly inflammable.

I am not certain, whether this Stratum does not contain ſo much inflammable Matter as to burn,

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(*u*) It is neceſſary to obſerve, that we ſhall employ the Term *Oil of Metals*, to expreſs that permanent Vapor, which has been commonly called *inflammable Air*, and *inflammable Gas*; becauſe neither of theſe Names could be admitted, conſiſtently with the Phraſeology adopted in this Work. Our Authority for the Uſe of this Term, is that of *Stahl* and Dr. *Fordyce*.

" A

burn, when once heated ſufficiently by other Subſtances; as happens with the aluminous Shale near Whitby; and there is a great Reſemblance between the common Stone-Coal and many Sorts of Shale. The Earth of Pit-Coal is alſo believed to be argillaceous.

The *Strata* of *calcareous Matter* are compoſed of Laminæ, more or leſs ſeparated by Shale, or Shiver, of the ſame Kind as the Stratum of that Subſtance incumbent on Lime-Stone. In many Parts, the calcareous Earth contains much phlogiſtic Matter, as appears from the fœtid Smell emitted on rubbing many Pieces of Lime-Stone, and which is then called *Stink-Stone*, or *Swine-Stone.* Within this Stratum are contained numerous Maſſes of *figured Stones*, which are evidently of *marine Origin*; ſome have the entire Shape of Sea Animals, others have only their Impreſſions. This Stratum has been, in many Parts, evidently fractured. Hence Chaſms have been formed, that are now filled up with Fragments of Stone; of which there is a remarkable Inſtance in the

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" A Metal in its metallic Form, is a Compound of a pure Calx, and a Subſtance which has been called inflammable Air; but which is an Oil, found out by Stahl, to exiſt in Metals, and which we would call *Oil of Metals.*"—Phil. Tranſ.—Dr. Fordyce's Method of aſſaying Copper Ores.

Mr. *Scheele*, alſo, calls inflammable Air, a *ſubtle Oil.*—*Treatiſe on Fire*, p. 158.

Vale

Vale at Matlock, where the Chaſm is filled with what is called *Rubble.*

Smaller *Cracks* and *Cavities* have been alſo made in this Stratum, which are filled up, and commonly called *Veins*; in Derbyſhire, *Pipes* and *Rakes*, according to their Directions.

Theſe *Pipes* and *Rakes* contain various *Metals*, *inflammable Subſtances*, and *Earths.*

Some of theſe Veins contain a *flinty* Subſtance only, called *Chort*, or *Chert*, which has been denominated organic ſilicious Earth, becauſe it has the Impreſſions of various Species of *Helmintholithi*, eſpecially of *Entrochi.*

Other Veins, from one to ſeven Yards thick, contain *calcareous Earth*, variouſly cryſtallized; viz. Spar, of a rhomboidal, cubical, priſmatical, and other Figures: Likewiſe the following Subſtances are found in, or upon theſe Strata.

Gypſeous Spar, a Compound of vitriolic Acid and Quick-Lime.

Cubic Spar, or *Fluor Spatoſus*, a Compound of Quick-Lime and Acid of Spar.

Amethyſtine, *Violet Spar*, or *Derbyſhire Spar*, popularly known by the Name of *Blue John*, of which ornamental Vaſes, Columns, Pyramids, &c. are formed, whoſe chymical Properties have not been enquired into, is only found in the Soil, in Nodules, upon the ſecond Lime-Stone at Caſtleton. This ſpar is phoſphoric.

A Subſtance named *Cauk*, or *Calk*, called Gypſeous, but improperly; for it is of late, I am told, found to be compoſed of *ponderous Earth* and *vitriolic Acid*. It is well known not to be fuſible, or not without a very great Heat.

Cawk, Chert, and *Dog-Tooth Spar,* have been noticed by the oldeſt Writers of the Natural Hiſtory of Derbyſhire. See *Woodward*'s Method of Foſſils, and Phil. Tr. Abr. Vol. VI. p. 291.

Kebble is different from, although frequently confounded with, *Cawk*; for I am told it melts without any conſiderable Heat.

Quartz Cryſtals in ſingle and double Parymids.

We find, a few Miles from Buxton, in looſe Maſſes, a little below the Surface of the Earth, ſome ſmall Quartz Cryſtals, vulgarly called *Buxton-Diamonds*; which are nothing more than Quartz coloured red by Iron (*x*).

Stalactites, or *Drop-Stone,* which is formed by a Depoſition from petrifying Waters in Caverns, and cryſtallized. It is much employed for making ornamental Vaſes, &c.

The Properties of many of the Spars are not underſtood.

But, the principal End for which Men deſcend into the interior Parts of the Earth in Derbyſhire, is to procure *Ores of Lead* that are here contained eſpecially in calcareous Spar and Fluor, ſometimes in Cawk. The Lead is combined, or mineralized, as it is termed, with Sulphur and Regulus of Arſenic. It is alſo mixed or united with other

(*x*) "Color omnis à Ferro."—Dr. Fordyce and Bergman.

Subſtances, as with a ſmall Proportion of *Silver*; and, perhaps, with *Antimony*, but this is uncertain. No Specimens of native Lead have been found in the Moor-Land of Derbyſhire. Theſe Ores are variouſly cryſtallized, and are of various Forms, when they are called *Steel-Grain-Ore*, *Bleyſchweiff* of the Germans; *Galena Plumbi*, *Bley-Glantz* of the Germans; and a particular Ore named *Slickenſides*, which has the Property of exploding, upon being ſcratched with a hard and ſharp-pointed Inſtrument, as it lies in the Vein. And there is alſo, I believe, *Lead Spar*, *Bley Spath*, which is Calx of Lead indurated, and cryſtallized.

Another Ore is likewiſe procured in the interior Part of the Earth of this Country in conſiderable Quantity, that is, Ore of *Zinc*; which is contained there in the State of a Calx, and known by the Name of *Calamine* and *Lapis Calaminaris*, *Gallmey* of the Germans; alſo *Zinc* mineralized with Sulphur, when it is denominated *Blende*, *Mock Lead*, *Pſeudo-Galena*; which, when mixed with a ſmall Porportion of Iron, is named *Black Jack*.

Iron mineralized with Sulphur, called *Iron Pyrites*, is here found in Abundance; and ſometimes alſo *Copper-Liver-Ore*, which, from exhibiting ſmall Stars, is called *Starry Malachites*; and that I believe is a Compound of Copper, Sulphur, and a ſmall Portion of Iron.

Antimony has been ſaid by ancient Writers to be found in the Mines of Derbyſhire; but I apprehend it was miſtaken for *Steel-grained Lead-Ore.*

It is not known, that any other Metals or Semi-Metals are contained in the Strata of Derbyſhire: *Cobalt* has been mentioned; but not upon ſuch Evidence as I could depend on.

The cold Springs in the calcareous Strata are many of them petrifying Waters; and thoſe near Buxton and Matlock are of the Temperature of about 48° to 50° of Fahrenheit's Thermometer. One of the Springs in this Region ebbs and flows. In other Parts of the Tract of high Land called the Engliſh Appennine, are more Inſtances of Springs of this Kind.

The preceding Account of the Structure and Contents of the internal State of the Earth of Derbyſhire, has been chiefly collected from Mr. *Whitehurſt*'s *Enquiry into the original State of the Earth*, to which excellent Work I refer the Reader for further Information; and alſo from *Ferber*'s *Verſuch einer Oryctographie von Derbyſhire*; which, however, contains nothing relating to ſubterraneous Geography but what was liberally communicated by Mr. Whitehurſt previouſly to the Publication of his *Enquiry*, and to whom Mr. *Ferber* acknowledges his Obligations.

We ſhall conclude the two foregoing Sections with a few Inferences and Obſervations.

Thoſe Perſons who are accuſtomed to reaſon concerning the original Formation and Compoſition of the exterior Part or Cruſt of the Earth, and concerning the Changes it is liable to undergo by ſubſequent natural Operations, from their Knowledge of the Natural Hiſtory of the Earth, and of the Effects of Nature, will, I apprehend, after reading the preceding Deſcription of the external Appearance, and internal Structure of the Earth in the Northern Part of Derbyſhire, allow the following Inferences to have been fairly drawn.

1. That the principal Part of the Subſtance which compoſes the Earth in this Region, has been formed by Matter depoſited from the Sea; for the Lime-Stone Beds that are ſuppoſed, with the greateſt Degree of Probability, to be of marine Origin, conſtitute by far the greateſt Portion of the Earth, of the Thickneſs with which we are acquainted.

2. That the Anglo-Appennine appeared firſt as a Ridge of Land above the Sea, while the other Parts of England were under Water; becauſe, it is preſumed, that this Region is the moſt elevated Land in England.

3. That many of the preſent Vales and Ravines with their Rocks and Cliffs, as well as the Holes and Caverns, have been formed by Torrents of Water, while the Sea was retiring, or the

antient Rivers contracting, and the dry Land was increaſing (*y*).

4. That ſubſequently to the Formation of the Britiſh Appennine, Beds of Lava were produced between the Strata formed by Depoſitions from Water, either by the Inflammation and Fuſion of inflammable Strata originally exiſting in the preſent Situation of the Toad-Stone Beds; or by liquid ſubterraneous Fires raiſed from Depths lower than the Parts in which they are now ſituated, and inſinuated and cooled between the Beds of Lime-Stone, leaving Beds of a Slag or Scoria, known by the Term of Toad-Stone; the Properties of which Subſtance, ſo far as hitherto known, we have above related (*z*).

The Strata of Lime-Stone incumbent on, or ſubjacent to, the Beds of combuſtible Matter in a State of Fuſion, would be partially at leaſt decompoſed, or converted into Quick-Lime; but as the Gas detached by the Heat of the melted

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(*y*) ——————" Vidi factas ex æquore Terras;
" Et procul à Pelago conchæ jacuêre Marinæ,
" Et vetus inventa eſt in Montibus Anchora ſummis;
" Quodque fuit Campus, Vallem decurſus Aquarum
" Fecit."

Ovid Metam. Lib. xv. Fab. 4.

(*z*) The firſt of theſe Opinions was ſuggeſted to me by a learned and ingenious Gentleman, to whom Philoſophy is under great Obligations for his Reſearches, whoſe Name I am not at Liberty to mention. The latter Opinion is well known to be that of Mr. Whitehurſt.

Earths would be contained in the Fiſſures and Cavities of the Earth communicating with the decompoſed Lime-Stone, from the ſtrong Attraction between Quick-Lime and Gas, the Lime-Stone Strata decompoſed would ſoon be reſtored to their original State of calcareous Earth; but by the Action of Fire would probably have the Figures of the Sea Animals of which they were formed wholly deſtroyed. One might alſo expect, that the Beds of Clay interpoſed between the Strata would be changed into Brick by the ſubterraneous Fires; and in this State they have been in ſome Places actually found; but as the Inſtances of this Change are few, it is probable, that ſome Cauſes, operating for ſeveral hundred thouſand Years, have totally altered the Form, and changed the Properties of the Clay ſo burnt; or, that the Beds of that Subſtance have been produced by Cauſes acting ſubſequently to the Formation of the Strata of Lava.

5. That the moſt conſiderable and evident Alterations in the external Form and Poſition of the Strata of the Peake, with which we are acquainted, have ariſen from Fractures of the Beds of Earth, in many Parts of the Country. In Conſequence of theſe, the horizontal or original Situation of the Strata is changed to that of being variouſly inclined to the Plane of the Horizon. In ſome Parts, one End of the fractured Stratum is elevated much above the other

End, and forms, perhaps, a Vale with ſtupendouſly abrupt Precipices on the one Side, and on the other inclining much below the Level of the oppoſite Side. Sometimes merely the fractured Ends are ſeparated, and form a Chaſm; at other Times the fractured Ends are concealed, by the Openings being filled up with Fragments of broken Strata, and covered with Soil: In ſome Inſtances, there is Reaſon to believe, the Strata have been burſt and opened, ſo as to entomb a great Part of the ſuperior Beds, previouſly ſhivered into Millions of Pieces, which are now in a great Meaſure miſſing; and from the inclined Poſition of the Strata, inſtead of finding the uppermoſt of one Kind, which muſt have been primitively the Caſe from their horizontal Direction, we find it conſiſts of all the various Strata we know. Whether throughout the whole Country, there exiſted *originally* the whole Set of Strata above deſcribed, of which, in particular Tracts, the uppermoſt are now miſſing, (either becauſe they have been ſwallowed up by ſubſequent Openings of the Earth, or becauſe they were originally wanting in thoſe Parts) is not clearly determined by any Monuments of Nature. We have no human Records of the preceding Events of Nature, nor could we have any from the Date at which they happened; but yet we conclude with Certainty, that they have occurred,

1. From the Order of Nature, obſerved with Regard to the Structure of the Cruſt of the Earth, which is compoſed principally of Strata, diſpoſed horizontally (*a*).

2. From comparing the Appearances of theſe Strata, with thoſe of other Countries in which we know they have been effected by the efficient Cauſe aſſigned. Here we deduce the efficient Cauſe from the Effects with the ſame Confidence that we do ſo in many Inſtances in common Life, where we have no Evidence excepting Effects: But theſe Cauſes and Effects being more familiar, are not queſtioned. Should I be acquainted with any Structure of human Workmanſhip, for Inſtance, that of a Grecian Temple, and ſhould I, thus informed, find the ſeveral Parts that compoſed that Structure detached from each other by being variouſly fractured, as the Columns in one Place, the Arch in another, and ſo on, I ſhould not conclude this was the original artificial State of theſe Parts; but that they are the ſeveral Pieces which once were joined in a certain Order, and formed that Structure called a Grecian Temple, although I have no other Evidence of this being the Fact, but that of my previous Knowledge of the Compoſition of this Piece of Architecture.

(*a*) "Par tout où il n'y à pas eu de Bouleverſment on trouve les Couches horizontales."——Buffon.

The ſame Concluſion is made, on other Occaſions, concerning efficient Cauſes, which we only deduce from the Ruins of Art, or Remains and Effects of Nature.

As an Example of ruptured Strata, and of the immediate Effects, and ſubſequent Changes in the external Form and Appearance of the Earth, which have gradually ſucceeded, we ſhall give a ſhort Deſcription of one of the moſt remarkable, and beſt known Fractures of any, in the hilly Part of Derbyſhire, viz. The Vale, or more properly Ravine, in which is Matlock Bath.

This *Ravine* is more than two Miles in Length, bounded on each Side by Rocks, ſome of which are awful and majeſtic Precipices, now partly concealed, in many Places, by Trees and Shrubs, that grow upon their Sides; and the River Derwent, of a reſpectable Magnitude, runs through the Middle of it. A Fracture of the Earth, to a conſiderable Depth below the Surface thereof, appears to have been the Occaſion of this romantic Scene. For at Matlock Bath, on the Eaſt Side of the Vale, there is a Cliff, or ſteep Precipice, about one hundred and twenty Yards in perpendicular Height above the River, wherein are expoſed to View the whole Thickneſs of the firſt Bed of Lime-Stone, the firſt Stratum of Toad-Stone, and the ſecond Stratum of Lime-Stone. A Stratum of Grit-Stone and another of Shale, one hundred and twenty Yards each, are incumbent on theſe Strata, yet they do not appear or make a Part of this Precipice, but are thereto wanting; as if they had originally appeared as the uppermoſt Part of the Cliff, but at a ſhort Diſtance from it had been cut down to the firſt Lime-Stone, and the whole Portion of Stratum of Grit-Stone and Shale between this Section and the Precipice had been afterwards removed.

At the Foot of this Precipice, compoſed of the above Strata, is interpoſed the River Derwent, and a Dyke or vaſt Gulph filled up with Fragments or broken Pieces of the ſuperior Strata, between the inferior or reſt of the Strata, viz. the ſecond Toad-Stone, the third Lime-Stone, the third Toad-Stone, and fourth Lime-Stone, and the Strata of the oppoſite Side of the Vale.

Theſe Strata on the Eaſt Side are rather elevated, ſo as to form a ſmall Angle with the Plane of the Horizon.

On the Weſt Side of this Vale, the Strata of Grit-Stone and Shale are entirely wanting, as well as a great Part of the firſt Lime-Stone; and the Set of Strata which correſpond in Quality and Thickneſs with thoſe on the oppoſite Side, are not only ſeparated or detached from them by the Dyke filled with Fragments under the River, but by their being much depreſſed towards the Part where the Rupture happened, beneath the Level of the correſponding Strata on the oppoſite Side, and ſo as to form a greater Angle with the Plane of the Horizon. For if the Space between the broken Ends of the fractured Strata were filled up, by making them touch each other, the firſt Lime-Stone and firſt Toad-Stone on the Weſt Side, would join the ſecond Toad-Stone on the oppoſite Side, and the ſecond Lime-Stone of the Weſt Side would join the third Lime-Stone of the Eaſt Side, and ſo on of the inferior Beds. The Depreſſion of the Strata on the Weſt Side is ſo great at the River, that they are there one hundred Yards below the Foot of Matlock-high-Torr; and form, by their Elevation above the Plane of the Horizon, ſo great an Angle, as that the Strata which compoſe the Top of Maſſon Mountain, are elevated two hundred Yards, or one hundred Fathoms above the Summit of Matlock-high-Torr.

The Gulph, or Dyke, now filled up with Fragments of Stone, is ſuppoſed to be the Part where the Earth opened during the Convulſion or Earthquake, that rent aſunder the whole Set of Strata, and ſwallowed up the two ſuperior Strata, and Part of the third Stratum, now miſſing on the Weſt Side of the Vale.

Here then, muſt have been the Theatre of an inconceivably grand and tremendous Operation, that burſt immenſe Beds of compact and ſtony Matter; ſhivered into Millions of Fragments two of the uppermoſt Strata, of the Thickneſs of two hundred and forty Yards; opened the Earth, and formed a Gulph, that ſwallowed up the ſhivered Beds, and whatever elſe was at that Time upon the Surface; perhaps, a large Town or City, together with many Thouſands of the ancient Inhabitants of the Iſland, and left the Strata in their preſent deranged State.

The Progreſs of Nature, during an immenſe Space of Time, amidſt the Ruins of Nature, produced by this deſtructive Convulſion of the Earth, and upon the Sepulchre, perhaps, of many Thouſands of our own Species, hath created Scenes that delight by their romantic and picturesque Grandeur;—ſuch natural Compoſitions as would be deemed worthy of Repreſentation on the Canvas of *Lorrain*. In like Manner, doth the caſual Operation of Nature, amongſt the Ruins of antient Edifices, frequently produce the moſt agreeable and affecting Pieces of Scenery; and which are ſelected as Examples of Compoſitions of Nature, that are capable of affording the higheſt Enjoyment to Men of Taſte, by their Beauty, or venerable Grandeur.

Another Effect of the burſting of the Strata is, the Appearance of the large Blocks or Ledges of Stone that are ſcattered upon the Surface of the Ground; for which we can aſſign no other Reaſon, but the Fracture of the Strata by ſubterraneous Blaſts.

6. As the Heat of the Springs iſſuing from the blue Clays, exceeds conſiderably that of ordinary Springs, and of the Earth in general, we conclude, that there ſtill exiſt either ſubterraneous Fires, or that the Heat of thoſe Fires which occaſioned the Derangement and Fracture of the external Subſtance of the Earth, is not yet extinguiſhed.

SECTION VII.

Of the Properties of the Atmoſphere of the Peake of Derbyſhire.

THE Difference obſerved in the Atmoſphere of different Regions, ariſes from

1. Their Weight.
2. Their Temperature.
3. The Kind, and Quantity of Subſtances *combined* with the reſpirable Air of the Atmoſphere.
4. The Kind and Quantity of Subſtances contained therein, in a State of *Diffuſion* and *Mixture.*
5. The Quantity, Frequency, and Form of Water, paſſing through them to the Surface of the Earth.
6. Their Motion.

CHAP. I.

Of the Preſſure of the Atmoſphere in the Peake of Derbyſhire.

THE Column of Atmoſphere incumbent on the Britiſh Appennine, is ſhorter than that of any other Part of England, becauſe the Land is more elevated above the Level of the Sea, or is farther removed from the Center of the Earth than any other Region of England; and therefore, the human Syſtem ſuſtains a leſs Weight of Atmoſphere in this Tract of Country, than in other Parts of the Iſland leſs elevated.

As the Atmoſphere has never been weighed at different Times and Seaſons, by Means of the Barometer, or ſtatically, we cannot ſtate the uſual Variations of Gravity in the Courſe of a Year or any given Time, the Duration of particular Degrees of Preſſure, and the Order in which theſe Variations have been obſerved to ſucceed each other; nor, conſequently, the preciſe Difference of Preſſure between this Atmoſphere, and that of other Regions.

However, from our Experience of greater Differences of Preſſure of the Atmoſphere than exiſt between that incumbent on the high Land of Derbyſhire, and that of any other Regions of the whole iſland, we are not diſpoſed to infer, that any Effects, or any conſiderable Effects, happen in the human Frame, *in a State of Health*, by even a ſudden Tranſition from any of theſe Regions to that of the Peake of Derbyſhire; but from our Experience of the Effects of leſſer Differences of vertical Preſſure than that ſubſiſting between the Atmoſphere of the Peake-Hundred, and the leſs elevated Regions of the Iſland, we conclude, that a ſudden Tranſition from many of the latter into the former, *in a State of Diſeaſe*, may induce conſiderable Changes.

Here, therefore, is a Principle for directing the Application, and explaining the Effects of this Atmoſphere in Caſes of Diſeaſe.

CHAP. II.

Of the Temperature of the Atmoſphere of the Peake.

NATURAL Hiſtory does not furniſh us with an Account of the Heat of this Climate, of its Variations, of the Succeſſion and Duration of various Degrees by the beſt Means of aſcertaining Degrees of Heat, the Dimenſions of Fluids, or thermometrical Obſervations; we therefore judge of the Temperature, by the Effects of this Atmoſphere on *the State of Vegetation*, the *State of Water as to Solidity and Fluidity*, and on *the Senſations*.—From theſe we learn,

That there is here conſiderably leſs Heat in the Courſe of a whole Year, certainly one fourth leſs

Heat

Heat than in the leſs eminent Parts of England. The higheſt Degree of Heat does not, perhaps, exceed that of the leſs mountainous Countries of the Iſland; but, perhaps, the Cold is of greater Degrees than in leſs elevated Parts. The Duration of the leſſer Degrees of Heat, too, is longer, and the Tranſition or Changes of the Degrees of Heat ſucceed in a different Order from thoſe of other Regions adjacent. The Degrees of Heat too, are very different from each other at the ſame Time, in this Tract of high Land.

For it is well known, that the Winters here, as well as upon the reſt of the Engliſh Appennine, are far more rigorous, and longer than that of the Lands adjacent, excepting a few Places in the Vales. The Ground is covered with Snow in greater Quantity, and much longer; and the Froſts continue much longer than in other Parts of England.

According to my Information, there is no Spring Seaſon in this County on Account of the Length of the Winter.

In a News-Paper for May 13, 1783, there is this Paragraph: "It appears from ſeveral People, who have come from the high Peake of Derbyſhire, and South-weſt Parts of Yorkſhire, that there is a great deal of Snow in thoſe Parts. It lay half a Foot thick in ſeveral Parts." It was at this Time mild, fine, and very warm Weather about Doncaſter, and there had been there no

Rain for more than two Months. Dec. 27, 1731, ſays Dr. Short, "there was a ſtrong North Wind at Buxton, and a clear Froſt, which in ſeven Hours Time bore Horſe and Rider, though it rained and ſnowed the Night before till two o'Clock in the Morning." Nat. Exp. Hiſtory, p. 46.

It is not till the Month of June, or Middle of this Month, I am told, that there are any Signs of Summer, or rather of warm Weather.

The Summer continues, commonly, till the Middle, or latter End of September; and during this Seaſon the Warmth is alternated frequently by cold or very cool Blaſts in the Day-Time for an Hour or two; and in the Night-Time it is, I believe, cooler than in the leſs hilly Countries. But, in ſome of the Vales, or Situations particularly favourable for the Action of the Sun's Rays upon the Sides of Hills, there is a more uniform and greater Heat than upon the Summits, and Places not ſheltered by Hills; ſo that, at the ſame Time, it frequently happens, that it is warm and agreeable in the former Situation, and cold, or diſagreeably cool, in the latter.

Vegetation, excepting a few cultivated Spots, or in ſome Vales and Situations favourably expoſed to the Beams of the Sun, does not manifeſt any Signs of Progreſs, or but a very ſlow Progreſs, till about the Month of June; and during the Summer, it is not more rapid, or not ſo rapid, as in leſs mountainous Countries in the ſame Latitude, or even in more northern Latitudes. So that, commonly many Vegetables produced in Gardens, do not grow, or do not thrive well, or not till late in the Summer; and, there are very few, or no Fruits that are well maturated.

The high Land, cultivated for Hay, produces but ſlender Crops, and is reaped the Beginning or Middle of September. The Hay-Harveſt in the Vales is earlier. The Corn that is grown in a few Spots only, is almoſt entirely Oats, and ſome Barley, which are reaped in October or November. There is not then Heat to a ſufficient Degree, or of ſufficient Duration, for the Vegetation of Plants that require but moderate and long continued Heat; as *Graſſes* for Fodder, and for Grain. *Ceres* and *Pomona* therefore, do not preſide in this Region:—It is the Seat of *Hygeia.*

Many Foreſt-Trees flouriſh here (*b*), and afford a moſt agreeable Screen againſt the piercing cold Northern Blaſts, when placed near the Habitations of the Moorland Shepherds.

This Account of the Temperature of the Atmoſphere, is perfectly like that of other mountainous Countries, and the Explanation is eaſy of the Occaſions of its peculiar Qualities.

There is a leſs Quantity of Heat produced in the Courſe of a whole Year, or indeed in any

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(*b*) "Amat Colles Pinifer Appenninus."——Sil. Ital.

given Portion of Time, in this Region of Derbyſhire, becauſe the Air is here leſs denſe than in moſt other Parts of England; whence the Rays of the Sun acting upon it being leſs refracted, produce leſs Heat: And there are no *local* Cauſes of Heat, to balance the Difference of the Degrees between this and leſs eminent Regions of Land, ariſing from this general efficient Cauſe, the Action of the Rays of the Sun upon the Air of the Atmoſphere.

Add to this general and principal efficient Cauſe, the greater Diſtance from the Seas than the Countries interpoſed between the Anglo-Appennine and the Iriſh Sea on the one Side, and the German Ocean on the other; in Conſequence of which, the Heat communicated from the Sea to the Atmoſphere in Winter, is too much diffuſed before it reaches the Middle of the Iſland, to make any conſiderable Addition to the Heat of the Atmoſphere occaſioned by other Means. During the Summer Seaſon, the Atmoſphere is rendered colder by the incumbent or adjoining Air imparting Heat to the Sea. This therefore is a Circumſtance that occaſions more Heat, all other Circumſtances being equal, in the Middle Parts of the Iſland, than in thoſe nearer the Sea; but this Circumſtance alone, is by no Means ſufficient to render the Temperature of this Region equal to that of leſs eminent Countries.

As there is a greater Degree of Cold in this Region in Winter, the Earth is cooled to a much greater Degree than in leſs elevated Countries, and conſequently requires a longer Time to be brought to the ſame Temperature, by the ſame Cauſes, than ſuch Countries. Here then is another Reaſon for the greater Length of the Winter Seaſon in the Peake, and one Occaſion of there being no Spring in this Region.

In the Vales, however, the Air being denſer, more Rays collected, and thoſe Rays being liable to be reverberated from one Side of the Mountains or Hills to the oppoſite Sides; the ſolar Rays too, acting againſt thoſe denſe and opaque Bodies, the Rocks and Cliffs of the Ravines and Vallies; conſiderably more Heat is there produced, than by the Sun's Beams acting upon the leſs denſe Air on the Summits of the Hills, and in leſs Number by falling upon leſs uneven Ground. The warm Air of the Vales carried by the Winds, and diffuſed through the cooler Air on the hilly Land, and likewiſe the reflected Heat from the Clouds or foggy Atmoſphere in Summer, occaſion the Atmoſphere of the Peake to be conſiderably more heated than it would be by the mere Action of the Rays of the Sun upon the Surface of the Ground, and the incumbent Air near the Earth. This Diffuſion of the warmed Air of the Vales through the cool Air of the Hills, affords an Explanation of the frequent Alternation of Warmth and Cold in the Courſe of a ſingle Day, during the Summer Months. We can alſo now well underſtand the other Effects of the Atmoſphere on *Vegetation*, *Water*, and the *Senſations*.

Among the occaſional Cauſes of greater Cold in the Peake, may be reckoned its natural Situation, as the Termination of the Ridge of high Land that communicates with Scotland. In Conſequence of this Circumſtance, Air blown from the North, muſt always be conſiderably cooler than if the Peake were a Tract of elevated Land connected with leſs eminent Countries to the Northward.

The practical Concluſions that may be drawn from this Deſcription of the Temperature of the Peake are,

1. That, during the Summer Months, which is the Part of the Year that Buxton is moſt reſorted to, Alterations are liable to be effected in the Habits of diſeaſed Perſons, if not by the Difference of Heat to which they are expoſed from that of the Countries from which they have come, at leaſt by the frequently alternate States of Heat and Cold of the Atmoſphere.

2. That, during the other Parts of the Year, Changes may be produced in States of Diſeaſe by the greater Degree of Cold of the Peake, than that of moſt other Regions, during the ſame Seaſon.

On the Contemplation of the Effects produced by theſe two Agents, muſt the Phyſician ground his Application of the Temperature of the Atmoſphere of the Moor-Land of Derbyſhire.

CHAP. III.

Of the Kind, and Quantity of Subſtances COMBINED *with the Air of the Atmoſphere.*

WE are only certain of two Things that *combine* with the Air of the Atmoſphere, viz. *Water* and *Phlogiſton* (*c*); but it is liable to contain a very great Variety of other Subſtances *ſuſpended* in, or *diffuſed* through it.

Water is found univerſally combined with Air; and as we have not been able entirely to deprive any given Maſs of Air, of Water, ſo we do not know the Properties of Air but when Water is a Part of its Conſtitution. So large a Portion of the Weight of any given Maſs of Air, ariſes from the Water it contains; and, as we diſcover more effectual Means of decompoſing the Compound of Air and Water, the more Water we are able to detach from it; it has been ſuppoſed, that Air was nothing but Water modified in a Manner not underſtood.

It has been lately aſſerted, that the Atmoſphere contained Water ſufficient to account for the *Sin-*

(*c*) *Gas* is alſo ſaid, by a celebrated *Chemiſt*, to *combine* with Air, but I am not acquinted with the Proofs of this Aſſertion. See *Bergman*'s Table of Elective Atractions.

Flood, were it all precipitated. This Explanation is not ſufficient to account for that Phænomenon; becauſe, let us ſuppoſe the whole Atmoſphere, inſtead of a Part only, to be Water in a State of Vapour, of the ſame Denſity as the atmoſpheric Air, the Atmoſphere would then balance or be of the ſame Weight as a Column of fluid Water of about thirty-five Feet in Altitude, or of a perpendicular Column of Quickſilver of about thirty Inches: Change the Atmoſphere of Water in a State of Vapour to a State of Fluidity, and the whole Earth will be covered by Water thirty-five Feet in Depth; but this would not be ſufficient to deluge the whole Earth, for this Quantity of Water would be contained in a few only of the Cavities and Vales, upon the Surface of the Earth. Such Cavities and Vales moſt certainly exiſted before the Deluge, as appears from Scripture; by which we are inſtructed that the Ark reſted upon Mount Ararat; and as may be demonſtrated by our Knowledge of the preſent State of the interior Structure, and external Form of the Earth.

The Quantity of Water that may be *combined* with Air, is in Proportion to the Denſity and Heat of the Air. It combines in a certain Proportion; after which, Water may be *diffuſed* through, and *ſuſpended* in, the Compound of Air ſo ſaturated with Water; and, from the frequent, and even daily Precipitations of Water, during the Summer Seaſon in the Peake, it is pretty certain the Air of the Atmoſphere muſt be there conſtantly ſaturated with Water: But this Fact has never been of any Application in Practice.

Phlogiſton, or the *Principle of Inflammability*, combines with Air, and forms a Subſtance that, like Air, is a *permanent Vapour*; but in other Properties theſe two Subſtances are totally different from each other. Air combined with Phlogiſton has been called, perhaps improperly, *phlogiſticated Air*.

The Atmoſphere, in every Part of the World, contains a larger or ſmaller Portion of phlogiſticated Air; for it is not only found in the Atmoſphere near the Surface of the Earth, and in the Air of large Towns, but at the greateſt Heights; as upon the Tops of the higheſt Mountains, and at immenſe Diſtances from Towns, or in uninhabited Countries. The compound of Phlogiſton and Air, or Air united with Phlogiſton, is readily diffuſed through the Atmoſphere; its ſpecific Gravity is very nearly the ſame as Air, under equal Circumſtances of Heat and Preſſure.

Animals are ſuffocated when *the Compound of Air and Phlogiſton* is applied to their Lungs inſtead of Air; and, when included in Receivers of Air containing a certain, but large Portion of this Species of permanent Vapor, namely, Air ſaturated with Phlogiſton, they will live juſt as long, as I have found by repeated Experiments, as if included in the Portion of Air alone, without the Addition of Air combined with Phlogiſton.

giſton. From general, but by no Means accurate Obſervations, it would appear, that the ſmaller the Portion of *the Compound of Air and Phlogiſton* is contained in the Atmoſphere of any Region, the more favourable is that Atmoſphere to the Duration of human Life, the Continuance of Health, and the Reſtoration of loſt Health. Yet I could relate Obſervations, demonſtrating the Reſtoration of Health in ſome Diſeaſes, to be as ſpeedy and compleat in Air containing a large Portion of phlogiſticated Air as in purer Air.

The Quantity of *the Compound of Air and Phlogiſton* in the Atmoſphere of any Region, we ſhould ſuppoſe, might be judged of by the Proceſſes in that Region which ſeparate Phlogiſton, or which are ſuppoſed to ſeparate Phlogiſton, or render the Atmoſphere impure; and by the Means there ſubſiſting of purifying it. The principal Proceſs that detaches Phlogiſton is *Inflammation.* The *putrefactive Fermentation*, and the *Reſpiration of Animals*, alſo *alter* Air, as is ſuppoſed, by ſeparating Phlogiſton, in the ſame Manner as it is altered by Inflammation; but the Identity of the Air altered by Reſpiration or Putrefaction, and Inflammation, has not been proved.

Putrefaction is not ſo conſiderable in the high Land of Derbyſhire as in many other Countries, becauſe the Quantity of Vegetables is leſs than in other Countries. The Heat, alſo, is ſo unfavourable as to retard, or prevent this Proceſs, a great Part of the Year. The Circumſtance of Moiſture of Soil is likewiſe wanting; for although Rains fall almoſt daily in Summer, yet the Water flows ſo ſpeedily, on Account of the Declivities of the Land, into the Channels forming Brooks, Rivulets, and Rivers, as to preſerve the Ground tolerably dry.

The *Phlogiſtication*, or ſome other Change of Air, by the *Reſpiration* of Animals, and by *Inflammation*, happens, in any conſiderable Degree, only in large Towns; of which there are none at a leſs Diſtance than twenty or thirty Miles from Buxton. The principal *phlogiſtic* Operation in the Peake, is the *Inflammation* in the Proceſſes for procuring Lead from its Ores; but, *the Air combined with Phlogiſton* formed by theſe Proceſſes, is but a ſmall Quantity, indeed, compared with the general Maſs of the Atmoſphere: For they are not conſtantly performing, and in Conſequence of the great Agitation of the Atmoſphere, the ſmall Quantity thus produced, is diffuſed throughout the whole Maſs of this Atmoſphere.

From theſe Conſiderations we ſhould be inclined to conclude, that the Atmoſphere of the Peake contains a ſmaller Portion of *the Compound of Air and Phlogiſton*, than the Atmoſphere of leſs elevated Regions in the ſame, or much more Southern Latitudes. But in order to form a proper Judgment of the Quantity of this Impurity in the Atmoſphere, we muſt not only contemplate the Sources of it, but the Means ſubſiſting of removing it.

The Means hitherto demonſtrated, or ſuppoſed to be proved, that are employed by Nature in the Purification of the Atmoſphere, are *Vegetation* and *Water*.

Much has been lately ſaid concerning the Influence of *Vegetation* on Air vitiated by phlogiſtic Operations; but the Effects of it, on the Atmoſphere, have not been ſatisfactorily explained.

The Experiments of Dr. Ingenhouz demonſtrate, that Vegetables expoſed to the ſolar Light, during the Performance of their Functions, excrete Air from their Leaves, Branches, and Stems; which Air, to the Teſt of Reſpiration and Inflammation, is frequently ſix or eight Times more pure than common atmoſpheric Air. The Experiments of this Philoſpher alſo inſtruct us, that living Vegetables, in the Abſence of Light, as in the Night-Time, and in the Shade, render Air noxious; but that the Effect of Plants in deteriorating Air in the Dark, is more than counterbalanced by their Power of meliorating common Air in the Day-time, when they are expoſed to the Solar Light (*d*). It is alſo rendered probable by the Experiments of ſeveral Philoſophers, eſpecially by thoſe of Dr. Prieſtley, that Vegetables abſorb certain Subſtances from the Atmoſphere, which render it impure.

Now conſidering the State of *Vegetation* in the Peake, we ſhould be inclined to infer, on the

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(*d*) Experiments upon Vegetables, 1780, 8vo. and Phil. Tranſ. Vol. LXXII. p. 429.

Foundation of the Reſult of the above Experiments, that the Atmoſphere here is, as far as depends upon living Plants, leſs pure than the adjacent and leſs eminent Countries; becauſe Vegetables are here leſs abundant, and grow leſs luxuriantly than in ſuch leſs elevated and neighbouring Regions. Moreover, the Quantity of *Solar Light* being much leſs, in this mountainous Tract of Country, than in moſt other Parts of England, this Circumſtance furniſhes another Ground for concluding, that the Vegetable Creation have here leſs Effect in purifying the Atmoſphere, by the *Addition* of pure Air, and *Abſorption* of Impurities, than in other Regions where the Quantity of Solar Light is much greater (*e*).

In

(*e*) My Readers will perceive, I have above delivered an Explanation of the Manner in which Vegetables purify the Atmoſphere, which is very different from that commonly received; and it therefore appears incumbent upon me, to ſtate the Grounds for my rejecting the Opinion uſually adopted on this Subject, and the Reaſons that have obliged me to embrace the Theory above propoſed.

Since the Publication of Dr. Prieſtley's Experiments on Air, and other permanent Vapours, the moſt prevailing, or only Opinion, concerning the Influence of Vegetation on the Atmoſphere has been, that Plants purified impure Air by abſorbing the noxious Part of it, which was commonly ſuppoſed to be phlogiſtic Matter; or by decompoſing it when it was unfit for ſupporting Life and Flame, by being combined, as was ſuppoſed, with Phlogiſton, (Pr. Vol. I. p. 49, 52, 87, 88, 93, 137, 141, 179, and other Parts of this Philoſopher's Ex-

periments

In this Enquiry into the State of the Atmoſphere of the Peake, with reſpect to its Impurities from Air rendered unfit for Reſpiration by Phlogiſton, or Subſtances ſuppoſed to vitiate Air by Phlogiſton, I ſhall in the next Place take Notice of the Situation of the Atmoſphere of

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periments and Obſervations.) This Opinion prevails on the Foundation of the Inference drawn by Dr. Prieſtley from his own Experiments; but as I am confident, according to my Judgment, that this Deduction is unjuſtifiable, the Opinion founded upon it is alſo, to my Apprehenſion, erroneous.

The Experiments of Dr. Prieſtley and others, ſufficiently prove, that *Air altered by Reſpiration, Inflammation, the putrefactive Fermentation, Volcanos, various Decompoſitions in the Practice of the Arts*, and other Operations, termed "Phlogiſtic," may be reſtored to its former reſpirable State, or even be made more pure than before it was *altered* by theſe Proceſſes; or be *exchanged* for common Air; and that common Air may be rendered more pure, by Vegetables growing therein. This Amelioration of impure Air may, at firſt View, appear to be equally well accounted for, upon any of the following Grounds: 1. By ſuppoſing the impure Part of the foul Air to be *abſorbed*, by the Plants to which it is expoſed. 2. On the Suppoſition, that this Sort of noxious Air is *decompoſed* by Vegetation. 3. By conceiving, that Vegetables, during the Performance of their Functions, *add* ſomething to the impure Air, which may be either merely *added* thereto, or which may be united with it. 4. By imagining, that this noxious Air may be amended, or impure Air rendered more pure, by ſeveral of theſe natural Means acting together.

However, after contemplating the Nature of the vegetable Powers, and conſidering more minutely the Experiments made with the View of determining the Influence of Vegetathis Country, with Regard to *Expoſure to large Bodies of Water*; for an Opinion is entertained by many, founded on an Inference drawn from Experiments, that large Quantities of running Water, as Seas, Lakes, Rivers, &c. purify Atmoſpheric Air of thoſe Impurities which are oc-

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tion upon impure, or wholly vitiated Air, I could not but draw a very different Concluſion from that of Dr. Prieſtley, and others, who have reaſoned like him; for I could only account for the Reſult of the whole of the Experiments on this Subject ſatisfactorily, on one of the above Grounds, on which is founded the Opinion advanced in the Page which refers to this Note; namely, that Vegetables may render noxious or impure Air more proper for Reſpiration and Inflammation, by an *Addition* of pure Air; which, according to the Idea of Dr. Ingenhouz, (Phil. Tranſ. Vol. LXXII. p. 427.) is ſeparated as an Excrement from them; and alſo, probably, in a ſmall Degree, by the Abſorption of certain Impurities. It is upon this Principle only, that we can ſatisfactorily explain all the Experiments made upon this Subject by Mr. Boyle, Dr. Hales, Dr. Prieſtley, Dr. Ingenhouz, Mr. Scheele, Mr. Bergman, and other Experimenters.

Mr. Boyle and Dr. Hales ſhewed, that the Vegetable Functions ſeparated a Subſtance, which was, apparently, a permanent Vapour, and which they ſuppoſed to be Air. Dr. Hales (Veg. Statics, Vol. I. p. 24, 30, 148, 153, 324, 358.) found, that Plants excreted, from their Leaves, Air moſt copiouſly, or only, at the Time they were expoſed to the Sun's Light, at which Time they were in a perſpiring State; but that in the Night-time, or Shade, no Air or Fluid, or only a very ſmall Quantity of them were excreted; and that the Plants were then in a State of Imbibition of watery Fluids, and permanent Vapour. As the Quantity of Fluid imbibed and per-

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caſioned by various Proceſſes named Phlogiſtic, viz. Reſpiration, Inflammation, Putrefaction, &c. either *by decompoſing the Compound of Air and Phlogiſton*, or *by abſorbing Subſtances ſuppoſed to be compoſed of theſe two ſimple Bodies.*

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ſpired was very conſiderable, being in twenty-four Hours, (Veg. Stat. p. 13.) ſeventeen Times more, Bulk for Bulk, than the Fluids entering and going off from the Veins of a Man in twenty-four Hours; and as the Quantity of Air ſeparated from Plants, appears to be in Proportion to the Quantity of Perſpiration, the Quantity of Air ſeparated, muſt be alſo conſiderable. "When," Dr. Hales obſerves, (Veg. Stat. p. 102.) "the Sun ſhined hot upon the Vine, there was always a continued Series of Air-bubbles conſtantly aſcending from the Stem, through the Sap in the Tube, in ſo great Plenty, as to make a large Froth on the Top of the Sap, which ſhews the great Quantity of Air which is drawn in through the Roots and Stem." The next Paragraph which I ſhall cite from Dr. Hales, inſtructs us, that the Sap roſe moſt copiouſly, only when the Sun's Light acts upon the Plant, and that it ſubſides upon the Intervention of a Cloud. Above it was ſhewn, by Dr. Hales, that Air was ſeparated moſt copiouſly under the ſame Circumſtance of Sun-ſhine. Theſe Obſervations coincide perfectly with the Reſult of the Experiments lately publiſhed by Dr. Ingenhouz, namely, that Plants, during their Expoſure to Sun-ſhine, ſeparate Air, which he found to be Air much purer than common Air; and in the Dark or Shade, they do not ſeparate Air, or only a ſmall Quantity of it, and in an impure State.

"If in the Morning, while the Sap was in a riſing State, there was a cold Wind, with a Mixture of Sun-ſhine and Cloud, when the Sun was clouded, the Sap would immediately viſibly ſubſide, at the Rate of an Inch in a Mi-

nute,

Conſidering the great Diſtance of the North Part of Derbyſhire from the Seas, and that the Rivers flowing through it do not contain a large Bulk of Water, we might infer, on the Foundation

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nute, for ſeveral Inches, if the Sun continued ſo long clouded; but as ſoon as the Sun-beams broke out again, the Sap would immediately return to its then riſing State, juſt as any Liquor in a Thermometer riſes or falls, with the Alternacies of Heat and Cold. Whence it is probable, that the plentiful Riſe of the Sap in the Vine, in the bleeding Seaſon, is affected in the ſame Manner." Veg. St. p. 115.

Dr. Ingenhouz has lately deciſively proved, (Phil. Tranſ. Vol. LXXII.) that the Bubbles of permanent Vapour, ſhewn by Dr. Hales to be ſo copiouſly excreted along with the perſpirable Matter of Plants, during Expoſure to the Light of the Sun, are Air much more pure than atmoſpheric Air; being, upon ſome Occaſions, ſix or eight Times more pure than common Air: Moreover, this learned Philoſopher has ſhewn, that Vegetables, eſpecially aquatic Plants, while immerſed in Water previouſly deprived of common Air, and with the Communication between this Water and the Atmoſphere intercepted by Quickſilver, excreted this pure Air as long as they live therein, in conſiderable Quantity; viz. about $\frac{1}{20}$ of the Bulk of the Water, beſides the Quantity *combined* and *mixed* with this Fluid, which may be reckoned at leaſt to be $\frac{1}{8}$ of the Bulk of it; or 160 Meaſures of Water will enable Plants to ſeparate 28 Meaſures of pure Air. And from the Experiments of Dr. Ingenhouz and Dr. Prieſtley, it appears that the Time Plants live and ſeparate Air, under theſe Circumſtances, is in Proportion to the Quantity of Water in which they are immerſed. Hence it may be very probably inferred, that pure Air thus ſeparated, is produced by the Vegetables, independently of the Abſorption of any common Air.

Foundation of the above Deduction, that the Atmoſphere was not expoſed to this Means of purifying impure Air, under ſuch favourable Cir-

cumſtances

Air, although they are capable of abſorbing common Air with their Food and Water (Hales Veg. Stat. p. 148, 149, 153, 155, 365.) This Inference, however, is deciſively proved to be true, by Experiments which ſhew, that when Plants are immerſed in unboiled Water, the common Air therein does not appear to have been abſorbed by the Plant, (Dr. Ingenhouz's Experiments. Phil. Tranſ. Vol. LXXII.) Dr. Prieſtley, however, deduces, that this pure Air ariſes from the common Air contained in the Water in which the Plant is immerſed, which is "depurated" by the vegetable Powers; which Deduction, however, as far as I am able to judge, if his own Experiments do not prove to be unjuſt, thoſe of Dr. Ingenhouz, (Phil. Tranſ. Vol. LXXII.) clearly demonſtrate to be ſo. The Quantity of pure Air, ſeparated by Plants immerſed in Water, is in Proportion to the Quantity of Water, not becauſe it affords common Air to be purified by the Plant, but, probably, becauſe it contains more Food to ſupport the Plant for a longer Time; or becauſe the perſpirable Matter, or other Excrements of the Plant, are noxious to the Vegetable from which they were excreted, and are rendered leſs hurtful when mixt with a large than a ſmall Quantity of Water. The Air excreted, although much purer than common Air, is an Excrement of the Plant, as much as its perſpirable Matter; and is thrown off as long as the Water can ſupply it with Food, provided it be not killed by the pure Air, its own Excrement, before this Food is conſumed, (Hales, Veg. Stat. p. 324. and Ingenhouz, Phil. Tranſ. Vol. LXXII.) Upon this Ground, alſo, may be readily explained thoſe Experiments of Dr. Prieſtley, which inſtruct us, that Plants live longer, and ſeparate pure Air, in Proportion to cumſtances as many other Countries in England ſituated nearer to the Sea or large Rivers; and that conſequently the Air of the Moor-Land of Derbyſhire, on this Account, is more impure than

the Quantity of Water, and dead animal or vegetable Matter, not exceeding a certain Quantity of theſe Subſtances, than in mere Water; becauſe, under this Circumſtance, more Food is furniſhed for the Plant, either by the animal or vegetable Matter commonly contained in Water, as well as the uſual Impurities of Water, or by the animal and vegetable Matter added to the Water; which Mucilage, as faſt as it advances to the State of Putrefaction, is abſorbed by the Plants, as their proper and pure Aliment, (See Dr. Fordyce's Elements of Agriculture.) This Theory, by the Way, explains why Water remains ſweet with Plants growing in it, although it contains Mucilage, that would, without the growing of Plants therein, ſoon render the Water fœtid, better than upon the Suppoſition, that Phlogiſton ſeparated by the Mucilage contained in the Water, is abſorbed by the Plants.

As a collateral Proof that Plants excrete pure Air from their Conſtitutions, and do not merely "depurate" or purify common Air contained in Water, may be ſtated, that ſome Species of Vegetables have been diſcovered by Dr. Prieſtley to contain pure Air in certain Receptacles, where it is found already excreted, as in the Air-Bladders of many Sea-Weeds; whereas Fiſhes contain in their Air-Bladders, Air totally unfit for Reſpiration.

It has been ſaid to have been the Reſult of an Experiment, that Water, expoſed to the ſolar Light, containing an opaque Subſtance, as Cloth, rendered impure Air as copiouſly as Water with Plants ſeparated pure Air; from which it was inferred, that the Water, not the Plant, afforded the Air by the Action of Light upon an opaque Body, but that the Plants purified it when thus ſeparated. This Experiment, on Repetition than that of other Regions more favourably ſituated for the Operation of Water.

After an attentive Peruſal, however, of the Experiments on which the Opinion concerning the Influence

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petition ſeveral Times, has been found to have produced a very different Reſult. See Ingenhouz's Exp. Phil. Tranſ. Vol. LXXII.

Light has been long known to be neceſſary to the Growth of Plants, but not ſo neceſſary as Air, (Dr. Fordyce's Elements of Agriculture.) The Manner in which ſolar Light operates upon the vegetable Powers, is not underſtood. It does not operate merely by the Heat it produces, as Dr. Hales ſuppoſed, (Veg. St. p. 130.) nor, as we ſhall explain below, in the Manner Mr. Kirwan ingeniouſly conjectures, viz. by the Light decompoſing the "phlogiſticated Air;" upon which Occaſion the Light unites with the Air, and the Phlogiſton with the Plant. (See Scheele's Treatiſe on Fire.)

It being deciſively proved, by the laſt Experiments of Dr. Ingenhouz, (Ph. Tranſ. Vol. LXXII.) that Plants excrete Air of ſix or eight Times the Purity of common Air, it may be readily conceived how it happened, that impure Air was meliorated in the Experiments of Dr. Prieſtley, and, after him, of other Experimenters, by Vegetation. For the *Addition* of a ſmall Quantity of this excreted pure Air, would be ſufficient to account for the Melioration, independently of any *Abſorption* of the impure Air. But as Plants alſo abſorb impure Air and various other Subſtances, ſuch as Oil of Metals, and Air altered by phlogiſtic Operations; and do not appear to abſorb the pure Air they have ſeparated; it is obvious Vegetables will abſorb the whole, or the greateſt Part, of the impure Air, and other Subſtances different from Air, and excrete the pure Air in Place of the Matter abſorbed: So that after Plants have grown a certain Time, under proper Circumſtances, Influence of Water in the Purification of the Atmoſphere is founded, I could not perceive, that they demonſtrated the Power of large Quantities

of

Circumſtances, in impure Air, Oil of Metals, &c. we find in the Veſſels, in which they were confined, a Quantity of pure Air, equal in Bulk, or nearly ſo, to the permanent Vapours and other Subſtances abſorbed. Dr. Prieſtley, I believe, firſt diſcovered that Plants grew when ſurrounded with Oil of Metals inſtead of Air; and that the permanent Vapour contained in the Jar filled with Oil of Metals becomes leſs and leſs inflammable, and more and more fit for Reſpiration; and, that at laſt the whole of the permanent Vapour found in the Jar is eminently proper for Reſpiration and Inflammation, and not at all inflammable. Now it is impoſſible upon this Occaſion, that the Plant could have converted the Oil of Metals into reſpirable Air; becauſe this Air is equal, in Quantity of Matter, to at leaſt ten Times the Bulk of the Oil of Metals ſubjected to the vegetable Powers in this Experiment; but upon the Principle of the Excretion of Air from, and of Abſorption of Oil of Metals by, the Plants, we can readily comprehend the Manner in which this Air was produced, and the Oil of Metals was loſt. This pure Air is excreted from the Plant independently of the permanent Vapour with which it was ſurrounded, excepting in ſo far as this ſurrounding permanent Vapour ſerves for, or is the Vehicle of, Aliment to the Plant. The luxuriant Growth of Plants in Oil of Metals, ariſes, probably, from this permanent Vapour ſtimulating the vegetable Functions; for this Subſtance is either not capable of ſupporting vegetable Life at all, or only for a ſhort Time.

Dr. Prieſtley, Dr. Ingenhouz, and other Experimenters found, that foul Air was frequently meliorated by Vegetation during Expoſure to the Sun-Shine, in a very ſhort Time, as in the Space of a few Hours, or perhaps a ſhorter Time. This

ſpeedy

of Water in rendering vitiated Air more fit for Reſpiration, by decompoſing *the Compound of Air and Phlogiſton*, and by abſorbing thoſe Impurities

ſpeedy Improvement of noxious Air may be eaſily underſtood, by aſcribing the Alteration to the *Addition* of pure Air, but cannot be explained ſatisfactorily, by the uſual Theory of the Melioration of vitiated Air by Means of Vegetation.

Perhaps it will be objected, that if the Improvement of vitiated Air, and Purification of common Air by Plants, depend upon the Addition of excreted pure Air, the Volume of the confined Air to which they are expoſed ſhould be augmented. To this Objection it may be anſwered, that when Experiments have been made to learn the Effects of Vegetation upon Air, the Bulk of Air has been rarely attended to, or at leaſt not properly;—that a ſmall Addition of pure Air will, frequently, be ſufficient to account for the Reſult; and that ſuppoſing no Addition of Volume be occaſioned, or even a Diminution thereof take place, this Event may be explained upon the Suppoſition, that the Vegetables abſorb either in the Day-Time or in the Dark, ſome of the impure Air, which Diminution may be about equal to the Bulk of Air added. Upon this Occaſion alſo, we ſhould conſider the Effect of the Water upon the confined permanent Vapour to which the Plants are expoſed, in uniting or mixing with it, and communicating it to, the external Air; and again, the Effect of the Water in combining or mixing with the Air of the Atmoſphere, and afterwards of ſeparating it in the Receiver containing the Plants and permanent Vapour intended to be made reſpirable.

Upon this Ground we can explain the Reaſon of the Failure of Plants in purifying or improving Air, namely, either becauſe there was not Light ſufficient, or ſome other Circumſtance was wanting to produce the Excretion of pure Air; or, becauſe there was preſent, ſome Means of deteriorating this purities called phlogiſtic Matter; on the contrary, I concluded, that they ſhewed the Effect of Seas, Lakes, and Rivers on the Atmoſphere, to be that of rendering it more impure, in as much as

Air when excreted: We can alſo underſtand how it has happened, that at one Time the ſame Plant amends noxious Air more ſpeedily, and to a greater Degree, than at another; owing to the Circumſtance of Light, Health of the Plants, State of the Water in which the Vegetable is confined, &c. Likewiſe we can readily comprehend how it happens, that the Quantity of pure Air ſeparated, is, to a certain Degree, greater in Proportion to the Bulk of Vegetables growing therein.

Vitiated Air, inſtead of being amended, is ſometimes deteriorated by other Means, beſides the Exhalations mentioned by Dr. Ingenhouz to be made in the Night-Time, from the Conſtitution of Plants in general, and in the Day-Time from their Roots, Flowers, and Fruits; of which we need not here particularly treat.

Common Air does not appear to contribute to the Production of the excreted Air of Plants, excepting, perhaps, in ſupporting their Life; for, in the Experiments of Dr. Ingenhouz, the common Air of the unboiled Water does not appear to have been abſorbed at all by the Plants, although this learned Philoſopher ſeems to have made a Deduction that it was abſorbed. Ph. Tranſ. Vol. LXXII.

We conclude, that although we allow the Inference to be juſt, that one Office of the vegetable Creation in the Syſtem of Nature, is to purify the Atmoſphere rendered impure by various Operations of Nature and Art, we cannot embrace the Opinion commonly received, that this Effect is produced by an Abſorption of certain Impurities, or by decompoſing that Compound, or thoſe Compounds, which conſiſt of Air unfit for Reſpiration and Inflammation by being combined with Phlogiſton, or other Subſtances.

Water appears to unite and mix with the pure Air of the Atmoſphere in larger Quantity, and preferably to thoſe Impurities called phlogiſticated Air, and phlogiſtic Subſtances (*f*). Pr. IV. p. 52, 158. Fontana, Phil. Tranſ. 1779, p. 439, 444. Dr. Forſter's Tranſlation of Scheele on Fire, p. 163.

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(*f*) Having, in the Page which refers to this Note, advanced an Opinion concerning the Influence of Water on the Atmoſphere ſo very oppoſite to that commonly received, I deem it neceſſary to ſtate the Grounds on which I have eſtabliſhed my Concluſion.

The Reſult of Dr. Prieſtley's Experiments, (Pr. Vol. I. p. 67, 68, 96, 97, 98, 100, 131, 161, 200, 201, 203, 246, 261, 269. Vol. II. p. 90, 267, and other Parts of his Works on Air) being, that after *Oil of Metals*, and *Air vitiated* or rendered unfit for Reſpiration, and decompoſing inflammable Bodies, by breathing, Inflammation, Putrefaction, Mixture with nitrous Gas, and a Variety of other Proceſſes, in which Phlogiſton either actually is, or is ſuppoſed to be, ſeparated and united with Air, has been agitated pretty violently and for a long Time, in wide Jars inverted and ſufficiently immerſed in a large Quantity of Water expoſed to the Atmoſphere, the confined permanent Vapours have been found wholly or partially in a State of Purity equal to atmoſpheric Air; this learned Philoſopher deduces, that by this Operation the *Oil of Metals* is changed, and the *vitiated Air* is reſtored wholly, or partially, to the State of atmoſpheric Air: And he conceives theſe Changes to be effected, by the Phlogiſton of the *Oil of Metals* being abſorbed by the Water, and by the Abſorption of the "noxious Effluvia," or Phlogiſton of the vitiated Air. This Inference Dr. Prieſtley employs as a Principle to explain the Purity, long believed to exiſt, of

Air

Since the farther Diſcovery of the Nature of that permanent Vapour formed by the Combination of a certain Proportion of nitrous Acid with Phlogiſton, hitherto called *nitrous Air*, or *nitrous Gas*, a Term we are under the Neceſſity of employing, (although it appears exceedingly improper)

Air of the Atmoſphere expoſed to Seas and other large Quantities of running Water: "Since, ſays he, Water in this Experiment muſt have imbibed and retained a certain Portion of the noxious Effluvia, before they could be tranſmitted to the external Air, I do not think it improbable, that the Agitation of the Sea and large Lakes may be of ſome Uſe for the Purification of the Atmoſphere; and the putrid Matter contained in the Water may be imbibed by aquatic Plants, or be depoſited in ſome other Manner." The Reſult above related, is ſufficiently eſtabliſhed by Dr. Prieſtley's Experiments, as well as by thoſe of other Experimenters; but the Inference drawn from them is very obviouſly doubtful, and in this Light it has appeared to the Author of a Treatiſe on *Gaſes*, who propoſes this Queſtion, p. 19. "Was the Melioration produced by the Water ſeparating the vitiated Part of the Air from the reſt by Abſorption, or by the Agitation effecting a Kind of Circulation between the external Air and the vitiated Air included in the Jars; by which Means, much of the former might be received into the Veſſels, while Part of the latter might be abſorbed by the Water, and thrown out into the open Air." With the utmoſt Deference to the Jndgment of Dr. Prieſtley, his Experiments, to my Apprehenſion, afford not only probable, but deciſive Proofs, that the confined permanent Vapours found in the Jars after Agitation in Water, in the Experiments above referred to, were not the permanent Vapours ſubjected to the Experiment *tranſmuted to the State of common Air*, by abſtracting proper) becauſe it has not yet obtained a more proper Denomination, and its being applied to determine the Quantity of extraneous Subſtances or Impurities of the Air of the Atmoſphere, it has been cuſtomary to eſtimate the Purity of common by Means of this Subſtance.

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abſtracting a Portion from them, or by decompoſing them, but were conveyed within the Jars from the Atmoſphere, while the Oil of Metals and vitiated Air were gradually mixt with the Water, and from thence communicated to the external Air. The Facts in Support of this Concluſion are the following. It appears from Dr. Prieſtley's Experiments, and thoſe of other Philoſophers, that if the permanent Vapours propoſed to be changed into reſpirable Air by Water, be expoſed to Water, ſo that a greater Portion of them be abſorbed without Motion, than happens after the Agitation by which reſpirable Air is produced, the Reſiduum is not different in Quality from that of the whole of the permanent Vapour before Abſorption. 2. That the permanent Vapour abſorbed by the Water, and again expelled, was not altered by being thus abſorbed. 3. That by agitating the permanent Vapours in a large Quantity of Water, in Veſſels with their Orifices cloſed, or in Veſſels with ſtrait Necks and their Mouths open, in a Trough of Water expoſed to the external Air, under which Circumſtances there was a much more ready Communication from the Inſide of the Jar to, than from, the external Air, no Alteration, or but a very partial Change, was effected. 4. That the Facility of the Production of common Air within the inverted Jar, was evidently in Proportion to the Opportunity of the Air of the Atmoſphere, when looſened from the Water by Agitation, entering within the inverted Jar, and of the permanent Vapour to be changed, being mixed with the Water, and from

thence

The Principle upon which this *Compound of Phlogiſton and nitrous Acid*, called *nitrous Air*, is applied for this Purpoſe, is this. *This Compound of Phlogiſton and nitrous Acid* doth not combine with any permanent Vapour, excepting *Air*; and the Phlogiſton combined with nitrous Acid in this

thence mixed with the general Maſs of Atmoſpheric Air; becauſe the Change intended to be made, was expedited by uſing open Jars with very wide Mouths, and by the Water in which it was agitated being expoſed to the Atmoſphere; and not by Agitation, and increaſing the Quantity of Water independently of the Uſe of wide Jars, and Expoſure of Water to the external Air. 5. That the permanent Vapours confined within the inverted Jar, were to the Teſtimony of the Smell ſhook into the Water, and from thence into the open Air. 6. That the Agitation of common or pure Air in Water, or mere Expoſure of them to Water, frequently injures them. 7. That merely transferring vitiated Air, or Oil of Metals through boiled Water, or Water free of Air, does not alter them. 8. That agitating permanent Vapours in unboiled Water increaſes their Bulk, by ſeparating Part of the Air contained in the Water. 9. That whatever Kind of permanent Vapour be agitated in Water, in Veſſels, provided it does not readily unite with Water, it may be exchanged for common Air, or Air rather worſe than common Air. The above Facts juſt related, if they do not demonſtrate the Truth of our Opinion, certainly render it highly probable. The following Reſult of an Experiment, however, may be conſidered as deciſive, as if it had been performed purpoſely to determine the Truth of the Opinions upon this Subject. Mr. Kirwan notices this Experiment, Phil. Tranſ. Vol. LXXII. P. 204. to ſhew, that the Experiments of Dr. Prieſtley do not prove, that the Oil of Metals conſiſts this Compound, is attracted by and combined with Air, without increaſing the Bulk of the Air, until it be ſaturated by this Phlogiſton ſeparated from nitrous Acid; till it be ſaturated, ſo far from increaſing, the Phlogiſton diminiſhes the Volume of the Air

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conſiſts of reſpirable Air "ſuperſaturated with Phlogiſton," 1 Pr. p. 67. After a Quantity of inflammable Air in a Glaſs Jar, had been agitated in a pretty large Trough of Water about ten Minutes, by which near one-fourth of its Volume had diſappeared, the Reſiduum combined with nitrous Gas, and an Animal lived in it as long as it uſually does in an equal Bulk of common Air; but it was ſtill weakly inflammable. In another Experiment, 1 Pr. p. 68. by continuing the Agitation ſtill longer than in the former Experiment, the Air which had been inflammable, ſuffered a Candle to burn in it; and by a ſtill longer Continuance of this Proceſs, it was in the State of Air in which a Candle had burned out. Upon this Experiment Mr. Kirwan remarks, "that it clearly follows, that if the external reſpirable Air had no Acceſs to the Inſide of the Jar, half nearly of the inflammable Air was converted into, or conſiſted of, reſpirable Air, ſince ſuch Quantity of Air was found in it after the Operation. Now it is impoſſible, that either could happen; for inflammable Air could not be converted into half, nor even one-third, or one-fourth of its Volume of reſpirable Air; as even one fourth of reſpirable Air contains more Matter than four Times its Bulk of inflammable Air; it is then evident, the external Air muſt have had Acceſs to it." Having preſented the Reader with a ſummary View of the Facts which, according to my Judgment, demonſtrate the Error of the Concluſion, that Oil of Metals and vitiated Air are capable of being changed into reſpirable Air by Agitation in Water; and conſequently, ſhown the Opinion found-

Air with which it is united, like other phlogiſtic Proceſſes in which Phlogiſton is ſeparated by the Attraction of Air, as in all Caſes of burning. Therefore, if to one Portion of Air without any extraneous Subſtances diffuſed through, or mixed

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ed upon ſuch a Deduction to be erroneous, I ſhall relate the Effects of Water upon the Atmoſphere, which appear deducible from the Reſult of the Experiments and Obſervations juſt related, on which is eſtabliſhed the Opinion, that *Seas, Lakes, and other large Bodies of Water, tend to render the reſpirable Air of the Atmoſphere more impure.*

Air altered by being united with Phlogiſton, or by Proceſſes of Nature and Art called phlogiſtic Operations, is nearly of the ſame ſpecific Gravity as common Air, and theſe two Subſtances are readily diffuſible through each other; ſo that the ordinary and almoſt conſtant Motion of the Atmoſphere, is ſufficient to diffuſe Air vitiated by phlogiſtic Proceſſes throughout the general Maſs of the circumambient Air.

Flowing Water, and Water in a *Still-ſtate,* being generally *ſaturated* with atmoſpheric Air, and alſo containing as much thereof as can be *mixed* with it, can have no Effect, according to any of the foregoing Experiments, excepting, perhaps, in vitiating the incumbent Air immediately in Contact with its Surface. Upon ſome Occaſions indeed by Variations of Temperature, and the Motion of the atmoſphere, Water upon the Surface of the Earth may ſometimes ſeparate Air, at other Times abſorb it.—The Air thus ſeparated, we infer, will at one Time be more pure, at another Time leſs pure than the common Air of the Atmoſphere; and that the Air abſorbed will be the moſt pure Part, or certainly the Water will not abſorb the vitiated Air preferably to the more pure Air of the Atmoſphere; ſo that with it, and to another equal Portion of Air containing a ſmall Quantity of *the Compound of Air and Phlogiſton* or other adventitious Subſtance, be added a Quantity of that *Compound of nitrous Acid and Phlogiſton,* called nitrous Gas, juſt ſufficient to

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Water in this its uſual State, rather tends to vitiate than render the circumambient Air more free of Impurities.

When the largeſt Bulks of Water upon the Surface of the Earth, as Seas and Lakes, are *agitated* conſiderably, as in Gales and Storms, it may be concluded from the Event of Experiments, that the Air already mixed with the Water, is by this Agitation detached and thrown into the common Atmoſphere, and the ſame Operation at the ſame Time mixes therewith common Air of the Atmoſphere. But as the principal Part, or indeed almoſt the whole of the Air ſeparated by this Means, muſt be obviouſly the common atmoſpheric Air, which was mixed with the Water by Agitation; the Influence of theſe large Quantities of Water, thus agitated, on the Purity of the Atmoſphere, we have no Grounds for ſuppoſing can be conſiderable.

We ſhall conclude this long Note with obſerving, that although no Experiments hitherto given to the Public, ſhow by what Means, Nature purifies the Atmoſphere from Air vitiated by phlogiſtic Operations, there are good Grounds for believing, that we know of a Means by which the Air, deſtined for the Support of Life and Inflammation, is deprived of a conſiderable Source of Impurity, namely, *Gas*; provided, this Subſtance be only contained in the Atmoſphere in a State of *Diffuſion*; or, that Water attracts it more ſtrongly than pure Air, if it be *united* therewith. (See *Bergman*'s Table of Attractions, and his Eſſay on the Uſefulneſs of Chymiſtry.) But of this Impurity we ſhall treat hereafter, in conſidering the Subſtances *diffuſed* through, and *mixed* with, the pure Air of the Atmoſphere.

ſaturate the *firſt* of theſe Portions, and the ſame Quantity of nitrous Gas to the other Portion of Air and adventitious Subſtances, the Reſult will be, that the Volume of the ſecond Mixture of this Compound of nitrous Acid and Phlogiſton or nitrous Gas and impure Air, will be *greater* than the firſt Mixture of this Compound of Phlogiſton and nitrous Acid and pure Air.

It is very certain, that this Principle is perfectly juſt and well founded; but on Account of the Difficulty of obtaining *exact Meaſures* of the permanent Vapours to be mixed together, and a Variety of other Circumſtances, this Method of determining the Purity of Air is either erroneous or impracticable; for it can only enable us to judge, as appears by many Experiments, of greater Differences, and ſuch as rarely exiſt between the Atmoſphere of different Places, ariſing from extraneous Subſtances; and from which could we determine this Queſtion by this Means, no practical Deduction of Utility could be made. It has been found, that an Animal lives *longer* in a Receiver containing a given Bulk of pure Air, than in the ſame Bulk of a Mixture of pure Air and *the Compound of Air and Phlogiſton*; from which we can only infer, that an Animal can breathe *longer* in pure Air, than in Air that contains foreign Matters: But the Inference is not juſt from this Experiment, that pure Air is more conducive to Health; or that impure Air, from the Admixture of *the Compound of Phlogiſton and Air*, is an efficient Cauſe of Diſeaſe. Again, extraneous Subſtances that are certainly known to be the Occaſion of Diſeaſes may be contained in Air, but which hitherto have not been, and probably cannot be demonſtrated by Means of nitrous Gas.

If, for Inſtance, I take a Parcel of atmoſpheric Air in a Region where an epidemic Fever, as the Plague, Intermittents, Small-Pox, &c. prevail; and another Parcel that is a Mixture of the pureſt atmoſpheric Air of a mountainous Country, and at the greateſt Diſtance from any Source of Impurity, and $\frac{1}{100}$ or $\frac{1}{200}$ Part of its Bulk of Air ſaturated with Phlogiſton, I ſhould find, after adding the ſame Bulk of nitrous Gas, and in ſufficient Quantity to ſaturate the Air of each Parcel, that the Bulk of the Mixture compoſed of the latter Air, or artificial Mixture of pure Air and *the Compound of Air and Phlogiſton*, and nitrous Gas, to be greater than the Volume of the Mixture compoſed of the former Air impregnated with contagious Matter, and nitrous Gas. The Inference from this Experiment muſt be, according to the preceding Principle, that the latter Parcel of Air being more impure, or containing more extraneous Matter, according to the Teſt of nitrous Gas, is more injurious to human Health than the former Parcel of Air, which contains indubitably the efficient Cauſe of Diſeaſes. How erroneous is this Concluſion! I do not know from Experience

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any Inſtance of Diſeaſe occaſioned by pure Air and a ſmall Proportion, as $\frac{1}{200}$ of its Bulk of *the Compound of Air and Phlogiſton*, or phlogiſticated Air; but it is needleſs to obſerve, that the former Parcel of Air is a moſt evident efficient Cauſe of Diſeaſe.

Moreover, on actual Trial, in many Inſtances at leaſt, this Teſt does not point out the ſmaller Differences of Climates, if they do exiſt, ſo as to be demonſtrable, by this Means, with any Kind of Uniformity or Certainty.

The following is the Reſult of ſome Experiments made to eſtimate the relative Purity of Air of the Atmoſphere of different Places and Regions, performed with Attention to all the known Circumſtances liable to occaſion erroneous Concluſions.

Two Meaſures, each of which contained ſix Drachms Meaſure, of Air appertaining to the Places and Regions under-mentioned, were added to one Meaſure of nitrous Gas: Each of the Meaſures was expreſſed by a Scratch upon a Tube, the Bore of which was about one-third of an Inch in Diameter, and each of theſe Meaſures was divided firſt into nine equal Parts, denoted by Marks made with a Flint upon the Glaſs, and then each of theſe nine Parts into four equal Parts. The Mixture of Air and nitrous Gas was made in a Phial, and after an equal Agitation and ſtanding for the ſame Time under equal Circumſtances of Heat, Preſſure, &c. in all the

Trials, it was transferred into the Tube juſt mentioned, and its Dimenſions noted.

Two of the above Meaſures of atmoſpheric Air, and one Meaſure of nitrous Gas, which occupied before Combination, a Space equal to 27 Diviſions of the above Tube, were, after Combination, reduced in Bulk as follows:

N° 1.	Air of the *Levels*, about fourteen Miles from Doncaſter, —	17½
	Ditto, ſecond Trial — —	16¾
N° 2.	—— Of Moſbro-Hall, ſix Miles from Sheffield — —	15¾
	Ditto — — — —	15½
N° 3.	—— From Sheffield — —	15¾
	Ditto — — — —	15½
N° 4.	—— From the Top of *Sir William*, a high Mountain, on the Road between Sheffield and Buxton — — —	15¾
	Ditto — — —	16¼
N° 5.	—— From the Aſhburne Road, a Mile from Buxton — —	16¾
	Ditto — — — —	16

N° 6.	—— the Macclesfield Road, a Mile from Buxton — —	16½
	Ditto — — — —	16
N° 7.	—— the Mancheſter Road, a Mile from Buxton — —	16
	Ditto — — — —	16¾
N° 8.	—— Fairfield, a Mile from Buxton — — —	16
	Ditto — — — —	15½
N° 9.	—— Doncaſter, in Marſh-Gate —	17½
	Ditto — — — —	17¼
N° 10.	—— Doncaſter, French Gate —	16¾
	Ditto — — — —	16½
N° 11.	—— Doncaſter, Hall-Gate —	16⅛
	Ditto — — — —	16
N° 12.	—— Doncaſter, Hob-Croſs-Hill	14¾
	Ditto — — — —	15½

The three firſt and four laſt Numbers of Air put to the Teſt of nitrous Gas, were collected the 4th of February, 1782, when the Weather was cold and there was a Thaw upon the Ground; the others, the Day following, in Derbyſhire, where there was a ſevere Froſt, and Snow lay upon the Ground. On the 7th of this Month they were combined with the ſame Parcel of nitrous Gas.

I was much diſappointed in the Reſult of theſe, as well as other Experiments, performed with the ſame View; for, having made no Trials myſelf, nor having then ſeen any made by others that contradicted or rendered queſtionable the Deductions and Opinions generally received, I was impreſſed with the Idea that I ſhould ſee conſiderable Differences, by Means of this Teſt, in the Air of the above Regions, uſually reckoned ſo different in Purity. I was unable alſo, after many more Trials beſides thoſe above related, to account for the *Want of Uniformity* in the Reſult on the Repetition of the Trials with the ſame Parcel of Air, and nitrous Gas. I afterwards aſcribed this *Difference in the Reſult* of the Trials with the ſame Elements, in Part to the Difficulty, or Impracticability of performing this Experiment with ſuch *Attentions* as ſhould not occaſion a Variety in the Reſult, independent of the State of the Air to be examined. But, I am now inclined to believe, the Varieties of the Atmoſphere of different Places as far as concern Health, are in general not demonſtrable by this Teſt; and that, generally, theſe Varieties only occur occaſionally, and that the Occaſion of them impregnate but a ſmall Portion of the Atmoſphere, when they are productive of Diſeaſes.

Since the above Experiments were performed, I find that Mr. Fontana, Mr. Cavallo, and other

Experimenters, agree with me concerning the nitrous Gas, conſidered as a Means of determining the Purity of Air of the Atmoſphere of different Regions.

C H A P. IV.

Of the Kind and Quantity of Subſtances, impregnating the Atmoſphere of the Peake, in a State of Diffuſion *and* Mixture.

THE moſt conſiderable and intereſting Effects on the human Syſtem produced by the Atmoſphere, are occaſioned by Subſtances *ſuſpended* therein.

Air, in all the various Degrees of the Heat of the Atmoſphere, is a permanent Vapour of great Rarity, being many hundred Times ſpecifically lighter than any Fluid we know; but, in Conſequence of its *Viſcidity*, it is capable of containing any Kind of Subſtances, provided they be divided into ſufficiently minute Parts; and we have actually found an infinite Variety of Things in the Atmoſphere; *permanent Vapours*, *Fluids*, and *Solids* of various Kinds; Animals and Vegetables: So that *Air* is never breathed, any more than Water drank, as a ſimple or elementary Subſtance, but as impregnated with various extraneous Matters. Of eleven or twelve Species of permanent Vapours with which we are acquainted, there are two which differ exceedingly in ſpecific Gravity; namely, *Gas*, an acid permanent Vapour, which is nearly twice the Weight of atmoſpheric Air; and *Oil of Metals*, which is ten Times or more, lighter than common Air; and they are all readily diffuſible through each other.

Of theſe Vapors, excepting *the compound of Air and Phlogiſton*, or phlogiſticated Air, above treated of, there are only two yet known that are *native Subſtances*, in any conſiderable Quantity, and that are liable to impregnate the Atmoſphere; namely, *Gas*, which, according to the preſent univerſal Opinion, is the ſame Thing as the *Mephitis* of the Antients, the *Choke-Damp* of the Engliſh Miners, the *Moffette* of the Italians, and the *volatile medicinal Principle of Springs*, eſpecially of the *Acidulæ*; and *Oil of Metals*, which is denominated by Miners, *Fire-Damp*.

Gas is contained in the Atmoſphere in Conſequence of its being extricated, during the Putrefaction of animal and vegetable Matters, by the chymical Analyſis of Subſtances, the Decompoſition of calcareous Earth in making Quick-Lime, from Rents or Fiſſures of the Earth, and Volcanos; from certain Lakes and Springs, eſpecially in Countries where ſubterraneous Fires exiſt; and, perhaps, it is ſeparated from the Lungs of breathing Animals; alſo it is poſſibly formed by the Union of Phlogiſton with Air in phlogiſtic Proceſſes.

During the putrefactive Fermentation, among other Subſtances ſeparated and mixt with the Atmoſphere, as well as during the chymical Analyſis of Subſtances, the Decompoſition of calcareous Earth by Heat, and, either ſpontaneouſly or by Means of Heat, from certain Spring-Waters, there is a *permanent Vapour* detached that combines with Quick-Lime, and therewith forms calcareous Earth; with cauſtic Alkali, and therewith forms mild Alkali; mild Alkali and this permanent Vapour combine and form a peculiar neutral Salt; and this permanent Vapour, unites with Water, and produces an acidulous Fluid; it alſo ſuffocates Animals that breathe in it, and it extinguiſhes Flame. During the Reſpiration of Animals, there is a *permanent Vapour* endowed with the above Properties, either precipitated from, or added to, the Atmoſphere; but a permanent Vapour, poſſeſſed of theſe Properties, is Gas.

It appears from the Writings of the antient Naturaliſts, and the *Poets*, of which Numbers are cited by *Pliny*, that the Properties of that Subſtance met with in the Bowels of the Earth, called now-a-days *Choke-Damp*, and that mephitic permanent Vapour denominated Gas, which iſſues from various Caverns, and Rents or Fiſſures of the Earth, eſpecially in Italy, where ſubterraneous Fires have exiſted for Ages, were as well underſtood ſome Centuries ago as at preſent; for they were known *to extinguiſh Flame* and *ſuffocate*

Animals, and no Perſon that I know of among the Moderns, hath demonſtrated more of their Properties. For who hath ever collected theſe Subſtances, queſtioned, and then diſcovered their Qualities? Or what Experiments have been made, excepting their Effects on Flame and the Reſpiration of Animals? Yet all have inferred from the above-mentioned two Qualities, *that the Choke-Damp* and *permanent mephitic Vapour*, ariſing from Apertures of the Earth, have the Properties above-related of Gas, and were denominated and conſidered by Experimenters accordingly (*g*).

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(*g*) Fixed Air is the oldeſt Fluid that hath been noticed by Mankind, ſince it is naturally found in many ſubterraneous Places, and from its killing Animals, and from its extinguiſhing Flame, the Miners call it Choke-Damp; but before Mr. Boyle, the Idea of it was very confuſed; and it was believed, that its fatal Effects were owing to a Vapour or *Spirit* diffuſed through the Air in ſome particular Places, hence it was called *Geiſt*, i. e. Spirit, whence the Word Gas has been derived, &c. It is found in various Mines, Wells, and Places not ventilated, and where it may be formed by a natural Fermentation and Combuſtion, as in the Vicinity of Volcanos, &c. People are found dead near Brick-kilns from fixed Air, and other noxious Vapours, during burning. The Grotto del Cane near Naples has been famous for Ages, in Conſequence of the Stratum of fixed Air which exiſts at the Bottom of it, and which is evidently emitted through the Fiſſures of the Earth. Animals of various Species and even Men have been killed by it, or deprived of their Senſes; and Light is commonly extinguiſhed in it. It is often mixed

As then it hath been only demonſtrated, that the permanent Vapours above-mentioned, *choke Animals* and *extinguiſh Flame*; and, as no Experiments or Obſervations have been made to diſcover more of their Properties, I ſubmit to my Readers, whether former Deductions be not unwarrantable, and that the juſt Inference was, that *theſe permanent Vapours were not Air*, or *Oil of Metals*; and that, as many other permanent Vapours, beſides Gas, ſuffocate Animals and extinguiſh Flame, it remains for future Obſervations

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ed with common Air, phlogiſticated Air, and inflammable Air.—*Cavallo* on Air and other permanently elaſtic Fluids.

" Dr. *Brownrigg* had the Satisfaction to find theſe Waters (Spa) pregnant with the *artificial* or *factitious* Air of Mr. Boyle, the ſame with that of the ſuffocating *Grotto* near Naples, and the ſame with the *Choke-Damp* of our Coal Mines; for as much as this Air inſtantly extinguiſhed Flame, and the Life of thoſe Animals he had incloſed in it."—Vide Sir *John Pringle*'s Diſcourſe on the different Kinds of Air, p. 11. 1774.

And the ſame Author ſays, p. 13. " I have been well informed, that for ſeveral Years paſt the learned Profeſſor (Dr. *Black*) has taught, that the Air which unites with alkaline Subſtances is of the ſame Nature with the *Mephitis*, or ſuffocating Air of the *Grotto del Cane* and Mines."

Dr. Brownrigg's Arguments (Phil. Tranſ. Vol. LV.), that the *Choke-Damp* and *fixed Air* are the ſame Subſtance, are, 1. becauſe *Choke-Damps* have been found to expire from the Earth in Parts near the *Acidulæ*, and produce the ſame Effects upon Animals as the *Choke-Damp*, or as the *Grotto del Cane* and other Caverns.

2. Theſe

tions to ſhew, whether they be Gas, or any of the other known permanent Vapours which ſtifle Animals, and in which Subſtances do not burn.

2. Theſe *Acidulæ* are really impregnated with a mephitic Exhalation reſembling the *Choke-Damp*, becauſe ſome of theſe Springs, as thoſe at Pyrmont, do plainly diſcover it by their deadly Effects upon Ducks ſwimming upon their Surface. 3. The briſk and pungent Taſte of the *Acidulæ* ſhews them to be related to the *Choke-Damp*, and to reſemble that from Beer and fermenting Liquors, which kills Animals like the *Choke-Damp*.

" A noxious Gas is found in many Caverns, as in the famous Grotto del Cane, in Mines, Wells, and other deep Pits. This Gas, which, by Engliſh Miners, is called *Choke-Damp*, is heavier than common Air, and therefore lies chiefly at the Bottom of Pits; extinguiſhes Flame, precipitates the Lime of Lime-water, and is noxious to Animals: From theſe Properties, which it poſſeſſes in common with the Gas obtained from calcareous and alkaline Subſtances, it has been reckoned to be of the ſame Kind, as that which has been deſcribed under the Name of calcareous Gas," (Fixed Air). See a Treatiſe on Gaſes, Chap. xiii. Pag. 75.

I ſuſpect two Properties are deduced by this laſt Author from other Properties; namely, that becauſe this Subſtance kills Animals, and extinguiſhes Flame, it therefore *precipitates Lime from Lime-water*, and *is of greater ſpecific Gravity than common Air*. That ſuch an Inference is liable to Error, has been before ſhewn.

Air of the former Kind, (fixed Air, or Choke-Damp) beſides having been diſcovered in various Caverns, particularly the Grotta del Cane in Italy, had been alſo obſerved on the Surface of fermenting Liquors, and had been called *Gas* by Van Helmont.—Dr. Prieſtley's Experiments and Obſervations on different Kinds of Air. Vol. I. Introduction, P. 3.

There are ſome Conſiderations which incline me to believe, that theſe Vapours are not Gas; at leaſt, that only a Part of them is this Subſtance: For they appear to be contained very generally in the Bowels of the Earth, in every Part of the Globe, into the interior Part of which we have penetrated; and, in many Countries, as for Inſtance, in the Weſt Riding of Yorkſhire, we can ſcarcely dig a Hole ten Yards deep, without meeting with the Choke-Damp; and yet the Springs of theſe Regions do not denote, by their acidulous Taſte, that they contain an unuſual Quantity of Gas. Now, we ſhould expect, that were this *Damp*, Gas, they would naturally contain a large Quantity, or be even ſaturated therewith. And, though the Exiſtence of theſe Vapours be very general throughout the whole interior Subſtance of the Earth, yet, not one Spring in a thouſand appears to be *acidulous*; or perhaps to contain any Gas combined with Water, as will be rendered highly probable, if not demonſtrated, hereafter. *Lavoiſier* ſays, " the Wells at Utrecht are from eight to twenty Feet in Depth, and the Water is raiſed by Pumps. They are covered with a Kind of Arch: When, after a certain Time, the Wells are opened on any Account, it is neceſſary to leave them uncovered for twelve Hours before any Perſon deſcends into them. Whoever ſhould venture to go down into them ſooner, would ſuffer inſtant Death." I ſhall obſerve upon the above Fact, that a Stratum of the Subſtance compoſing the *Damp*, muſt be ſuppoſed to be formed upon the Surface of the Water. Now were this Stratum Gas, the Water muſt be *acidulous*, becauſe, before it could be ſeparated therefrom ſpontaneouſly, it muſt be more than ſaturated therewith; and whenever Gas exiſts, as a Stratum upon any Spring, it may be pronounced, that the Water is ſaturated with this Subſtance, and that the Gas which is upon its Surface is what is called *ſuperfluous*.

Secondly, Theſe ſubterraneous Vapours can only be accounted for, by the Fires that have ſubſiſted, or do ſubſiſt, in the internal Parts of the Earth; and although the chymical Analyſis, produced by this Means, may, probably, ſeparate Gas, as in the burning of Subſtances upon other Occaſions; yet, from Analogy we ſhould ſuppoſe, this will not be ſufficient to fill the Vacuities of the Bowels of the Earth with Gas, and ſaturate the Springs that have flowed through Paſſages communicating with thoſe Cavities for ſeveral thouſand Years. In Countries where no ſubterraneous Fires have apparently ſubſiſted, as in the Engliſh Appennine, for, perhaps, a hundred thouſand Years paſt, the Springs flowing for this Period, have, in all Probability, carried off all the Gas detached by the ſubterraneous Heat. Let us even ſuppoſe, the whole Strata of calcareous Earth to be decompoſed by ſubterraneous Fires, it is not likely, that the Gas would remain for many thouſand Years in the Crannies and Caverns of the Earth, probably, expoſed to the Action of the Strata of quick Lime, by Means of Cavities in which the Gas was contained communicating therewith, though at a conſiderable Diſtance, and certainly to ſubterraneous Streams of Water, without being wholly combined with one or both of theſe Subſtances.

Having given the Reaſons which incline me to believe, that theſe mephitic Vapours, or *Damps*, are not Gas, I ſhall ſtate the Arguments, which, to my Apprehenſion, render it probable that they are entirely, or principally, *the Compound of Air and Phlogiſton*, or Air united with Phlogiſton.

The external Part of the Earth, in every Part of the World yet explored, has been infeſted, or is infeſted, with ſubterraneous Fires; as appears by the Derangement of the Strata, the Appearance of Earthquakes, and the Eruption of Volcanos; and, conſequently, there muſt have been an immenſe Quantity of *the Compound of Air and Phlogiſton* formed, far exceeding the Quantity of Gas ſeparated by this Combuſtion. But *the Compound of Air and Phlogiſton*, is abſorbed in a ſmall Proportion, by pure or elementary Water, and that very ſlowly: And, the Rain-Water which forms Springs being ſaturated, or nearly ſo, with Air, does not abſorb any, or but a ſmall Quantity, of this *Compound of Air and Phlogiſton.* (See Part III. Exper. xli, xlii. of this Work.)

Therefore, on the Suppoſition of theſe ſubterraneous permanent Vapours, being *the Compound of Air and Phlogiſton*, and not Gas as is commonly ſuppoſed, we can account for its Origin and Subſiſtence on more probable Grounds, than upon any other Suppoſition.

In Countries where there are frequent Eruptions of Volcanos, the mephitic Vapours expelled by Rents in the Earth, and from Caverns, are probably, a Mixture of various Kinds of permanent Vapour, that are formed or ſeparated during the chymical Analyſis of inflammable Subſtances; namely, *Gas*, *Oil of Metals*, and *common Air*, as well as *the Compound of Air and Phlogiſton*; becauſe the Springs have not had Time to combine with, and waſh off, the three firſt permanent Vapours.

We can now account for the Origin of *the Compound of Air and Phlogiſton*, in every Part of the Atmoſphere, from the Quantity of that Subſtance exhaled from the Earth in many Countries, and its conſequent Diffuſion through the general Maſs of the Atmoſphere; as well as from the Quantity produced, by various Operations, upon the Surface of the Earth, in which Phlogiſton is ſeparated.

It hath been demonſtrated, that certain Springs emit, either ſpontaneouſly, or by the Application of Heat, Gas, which, like all other permanent Vapour excepting Air, ſuffocates Animals and extinguiſhes Flame; and, as ſeveral Fountains have been found to kill Animals on drinking them, or approaching near them, it hath been concluded, that they, upon all Occaſions, produced this fatal Effect by the Gas they ſeparated. The Lake *Avernus* was, in antient Times, as famous in Hiſtory for its Power of deſtroying animal Life, as the *Grotto del Cane* is at preſent (*b*).

> Quam ſuper haud ullæ potèrant impunè volantes
> Tendere iter Pennis, talis ſeſe Halitus atris
> Faucibus effundens ſupera ad convexa ferebat:
> Unde locum Graii dixerunt nomine Avernum.
> VIRGIL, Lib. VI. Æn.

(*b*) "There are upon Mount Ætna ſeveral Springs, ſome of ſo deadly a Quality, that Birds and Beaſts have been found lying dead on their Banks, from having drank theſe Waters." (See Brydone's Tour through Sicily and Malta, p. 250.)

"Virgil, and other Authors, ſay, that Birds cannot fly over the Lake *Avernus*, but that they fall therein; a Circumſtance favouring my Opinion, that this was once the Mouth of a Volcano; and I am convinced, that there are ſtill ſome Remains of this Vapour upon this Lake, as I have obſerved, there are very ſeldom any Water-Fowl upon it; and when they do go there, it is only for a ſhort Time, whilſt all the other Lakes, in Winter Time, are conſtantly covered with them." (Vide Sir William Hamilton's Account of Volcanos.)

Mr. *Addiſon*, in his Travels through Italy, ſays, "there is nothing now particular in the Lake *Avernus*, formerly famous, according to Virgil, for its Steams of Poiſon, for it is plentifully ſtocked with Fiſh and Fowl."

It is moſt probable, that the permanent mephitic Vapour that ariſes ſpontaneouſly from Waters, is more frequently *the Compound of Air and Phlogiſton* than Gas; and for the ſame Reaſons that inclined me to believe, that the Choke-Damp, or *Mephitis*, was *the Compound of Air and Phlogiſton* rather than Gas; but this Queſtion may readily be determined by the *Taſte* of the Water. If it be not *acidulous*, it certainly does not produce fatal Effects by the Gas it ſeparates ſpontaneouſly; becauſe, before it could extricate this permanent Vapour, it muſt be ſaturated therewith: If it be *acidulous*, it moſt probably chokes Animals, in Conſequence of the Stratum of Gas apt to form upon its Surface. Moreover, if the Water be near any Volcano, or Rents of the Earth emitting *Moffette*, the Probability is, that it abounds with *the Compound of Air and Phlogiſton*.

Sir *James Lowther* collected, many Years ago, a Bladder-full of that ſubterraneous Vapour, called the *Fire-Damp*; by which Means, this Subſtance was aſcertained to be Oil of Metals. If ſome Perſon would be at the Trouble of procuring a Parcel of the Choke-Damp, it might readily be determined whether it be Gas, or *the Compound of Air and Phlogiſton*, or ſome other permanent Vapour.

The Gas contained in the *Acidulæ*, and that which is diſcharged through Rents of the Ground, may ſometimes be produced in the Bowels of the

Earth, by the Combination of Acids with abſorbent Earth, as by the Combination of calcareous Earth with the vitriolic Acid of Pyrites: But the principal Source we know of, is the Decompoſition of calcareous Strata, and the chymical Analyſis of inflammable Matters; for it is not yet rendered perfectly clear, that Gas is formed by the Union of Phlogiſton and Air, in all Proceſſes in which Phlogiſton is ſeparated.

Oil of Metals we infer, is contained in the Atmoſphere, becauſe it is produced by the Putrefaction of Vegetables and Animals in large Towns, marſhy Grounds, many Ditches, and boggy Places; and is moſt copiouſly diſcharged from the Bowels of the Earth, by Means of Springs, which are well known by the Flame produced near their Surface upon the Approach of a lighted Candle; probably alſo by Rents in the Earth, and the Eruption of Volcanos.

It is produced in the Earth, during the chymical Analyſis of the inflammable Matter of ſubterraneous Fires; which, therefore, accounts for the Origin of the *Fire-Damp.*

In Derbyſhire we have three peculiar Sources of the permanent Vapours here treated of, namely, *the tepid Springs of Buxton,* which ſeparate ſpontaneouſly a Subſtance that is probably *the Compound of Air and Phlogiſton,* to be fully deſcribed hereafter; the *Decompoſition of Lime-Stone* in the making of Lime, in Conſequence of which the Atmoſphere is conſtantly impregnated near Buxton with Gas, and a ſmall Quantity of *the Compound of Air and Phlogiſton*; and the Proceſſes for making Lead, that extricate or produce Gas, Oil of Metals, and *the Compound of Air and Phlogiſton*. From a Contemplation merely of the Sources of theſe permanent Vapours, excepting thoſe Sources juſt mentioned, we ſhould be inclined to infer, that a ſmaller Quantity of theſe two Impurities, viz. *the Compound of Air and Phlogiſton*, and *Gas*, is contained in the Atmoſphere of the Peake, than in almoſt any other Part of England. The Quantity of theſe permanent Vapours does not appear to be ſo great, as to occaſion any Apprehenſion of bad Effects from breathing the Air at, or in the Neighbourhood of Buxton; excepting upon a near Approach to the Subſtances ſeparating them, and when the Air is little agitated by Wind.

To form a Judgment of the Quantity of Impurities in any Part of the Atmoſphere, we muſt not only conſider their Sources, but whether any Means exiſt in Nature of removing them. We have already conſidered the natural Means exiſting of purifying the Atmoſphere of the Peake, from Air vitiated by Inflammation, Reſpiration, &c. called, perhaps improperly, phlogiſticated Air, but we have reſerved for this Place the Conſideration of the Proviſions in Nature for purifying atmoſpheric Air of Gas: For, as the

Quantity of this Subſtance continually ſeparated or formed, and mixed with the Atmoſphere, is very conſiderable, the common Air deſtined for the Support of Life and Inflammation, would probably be rendered incapable of ſerving for theſe Purpoſes, were there no Means provided of freeing the Atmoſphere from this Impurity.

Vegetation has no Effect, as far as we know, of purifying the common Air of Gas, whatever may be the Effect of this Operation on other Impurities of the Atmoſphere.

Air rendered impure by *Gas*, may be purified by fixt vegetable Alkali, as ſhown long ago by Dr. Hales; which Effect may be now explained by Mr. Bewly's Experiments (*i*), which demonſtrate that mild Alkali, (a Subſtance compoſed of cauſtic Alkali united with Gas,) unites with Gas, and forms a neutral Salt. There have been alſo various other Subſtances diſcovered ſince the Experiments of Dr. Hales, which free Air of Gas when theſe two Subſtances are *diffuſed* through each other, or perhaps *combined* together. Among theſe Means of purifying Air of Gas, there is one exiſting in great Abundance, and which even makes no inconſiderable Part of the Globe itſelf, which there can be no Doubt in conſidering to have great Influence on this Impurity, provided theſe two Subſtances be placed under

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(*i*) See Appendix to Dr. Prieſtley's Experiments and Obſervations, Vol. II.

Circumſtances in which they exert their Attractions upon each other. This natural Means is the *Water* of Seas, Lakes, Rivers, Brooks, &c. It is upon this Ground only, Dr. Fordyce explains the Office of *Water* in Nature of purifying the Atmoſphere; and he makes a moſt ingenious and original Obſervation upon this Subject, which enables us to underſtand clearly the Action of Water upon the common Air intended for Reſpiration and Inflammation, and to interpret various natural Phænomena. He obſerves that Gas, being much ſpecifically heavier than Air, and not being united with it, muſt occupy, or be conſtantly tending to occupy, the loweſt Parts of the Atmoſphere, and conſequently be more liable to be abſorbed by Water upon the Surface of the Earth. This Property, together with the Agitation of the Atmoſphere, and the Motion of theſe Waters, are Circumſtances ſufficient to produce a Combination of the Gas contained in the Atmoſphere with the Water upon the Surface of the Earth.

Now conſidering that the Quantity of flowing Water upon the Surface of the Land in the Peake is not ſo great as in many other Countries; and that this Region is nearly in the Middle of the Iſland, between the German Ocean on one Side, and the Iriſh Sea on the other, we may infer, that the common Air of the mountainous Part of Derbyſhire is, on this Account, liable to contain a greater a greater Quantity of Gas than many other Climates of this Iſland. Whether this be the Fact or not, muſt depend upon the Reſult of the Enquiry hereafter to be made, concerning other natural Means of ſeparating Gas from the Atmoſphere, or of diminiſhing its Effects as an Impurity.

There are many Subſtances in a State of *Fluidity* contained in the Atmoſphere, but, of theſe, *Water* only is there *ſuſpended* frequently and generally in Air that is reſpired, and by which Effects are known to be produced on the human Frame in every Part of the Earth.

In the Peake of Derbyſhire the Atmoſphere is more frequently blackiſh or dark-coloured, miſty and foggy, and ſenſibly humid, or betokens Humidity or Dampneſs, by altering the Dimenſions of Subſtances, more frequently than in the leſs eminent Countries adjacent.

Moreover, the Clouds, which are nothing but Portions of Air, with Water ſuſpended in them, in this Tract of high Land, are ſuſpended near the Surface of the Earth, and frequently reſt upon the Summits of the Hills, or are intercepted in their Paſſage from one Part to another by the Mountains, againſt the Sides, or on the Tops of which they are frequently obſerved to reſt. This humid or hazy Atmoſphere, frequently prevails for ſeveral Weeks together in Summer. Either this State prevails, or the Tranſitions from a ſerene to a cloudy Sky, happen almoſt daily; ſo that a Perſon, judging of the State of the Weather in this Country, according to what he has obſerved in leſs mountainous Regions, would be much deceived; for it is very common to have a dark black Morning threatening, according to uſual Appearances, a rainy Day, although this Appearance ſoon changes into a ſerene Sky. The reverſe of this as frequently happens.

It has been humourouſly ſaid, on Account of the frequent cloudy Weather, "that the Sunſhine is juſtly reckoned one of the Wonders of the Peake."

I ſhall premiſe a few general Obſervations, after which there will be no Difficulty in explaining theſe Appearances of the Atmoſphere, in the North Part of Derbyſhire.

It has been before obſerved, that Air diſſolves Water (*k*), or that Water is poſſibly a conſtituent Part of Air. Air containing Water in a State of *Solution*, is perfectly dry; and the moſt tranſparent Subſtance in Nature:—is that Subſtance which, of all Things, bends or refracts leaſt the Rays of Light in their Paſſage through them.

The Law relating to Solution in Fluids, obtains with permanent Vapours, in ſo far as *the Quantity of Water a given Portion of Air can diſſolve is, cæt. par. in Proportion to its* HEAT. But there

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(*k*) Phil. Tranſ. Vol. LV. Art. xxiii. on Evaporation, by Dr. Hamilton.

is, alſo, another Law governing Solution in permanent Vapours, which is, *that the Quantity of Fluid an aſſigned Portion of permanent Vapour can diſſolve, is, cæt. par. in Proportion to its* DENSITY.

When a Menſtruum is ſaturated with any Solvend, it may have any Portion of the Solvend diffuſed, or mixed with it. For Inſtance, after fixed Alkali is ſaturated with acetous Acid, any Portion of this Acid may be diffuſed through the neutral Salt formed of acetous Acid and fixed Alkali.

Dry Air which is ſaturated, or nearly ſaturated with Water, and denſer, and nearly as warm or warmer than the Atmoſphere of the Peake, when blown into this Country, will be pretty certainly rendered leſs denſe, and moſt probably, be cooled; in Conſequence of which, the ſolvent Powers of this Air being diminiſhed, it will be apt to precipitate Water; and if only ſuch a Diminution of theſe Powers take Place, as to precipitate a Portion of Water that ſhall not be able to overcome by its Gravity the Coheſion of the Air, it will remain ſuſpended, and produce a humid, and leſs tranſparent or turbid State of the Atmoſphere. This rainy or foggy Weather may happen, whenever the Wind blows from any Point of the Compaſs, excepting that which carries Air from the Northward directly along the Courſe of the Anglo-Appennine, and continue for ſeveral Weeks, provided Air of the Properties, and from the Points of the Compaſs above-mentioned, be blown during ſuch a Time into the Peake.

The alternate States of tranſparent and cloudy Skies, that take Place almoſt daily in Summer, are probably occaſioned by the warmer and denſer Air of the Vales being blown over the higher Land. The Air from theſe Places, may be conſidered as only *Portions* of ſuch Air as were above ſtated to be blown for a longer Time; and conſequently their Effects are only of a ſhort Duration.

The Atmoſphere is only able to ſupport Clouds for a certain Height, above the Level of the Sea. In Countries where the Altitude of the Land is conſiderably above the Level of the Sea, Clouds are apt to creep near, or upon, the Surface of the Ground; and in their Paſſage through the Atmoſphere, are liable to be intercepted and attracted, by the Summits, or Sides of the Mountains; therefore, as the Peake is much higher in the Atmoſphere than the Land of the neighbouring Countries, the Hills are frequently obſerved to have Clouds reſting againſt their Sides, and crowning their Tops. The turbid State of the Atmoſphere in this Region, and the Appearances in Conſequence of this State, agree with thoſe of the Atmoſphere of other elevated Tracts of Land; in which, alſo, the Water ſuſpended in the Air, hath been obſerved by hygrometrical Obſervations.

As it has been long obſerved, that the human Conſtitution, both in Health and Diſeaſe, is much affected, in many Caſes, by Moiſture of the Atmoſphere, it will be neceſſary, that the Effects of this humid State of the Air of the Peake, be conſidered in Practice.

Beſides the above-mentioned Subſtances, which are *diffuſed* through the Atmoſphere, of probably, every Part of the Globe, there are a great Number of foſſil Subſtances; to wit, Acids, Alkalies, Earths, metallic Subſtances, and Inflammables; alſo, various Kinds of permanent Vapours, with the Properties of which, we are not acquainted, to be able to refer them to any particular Species of Things; liable to be contained in the Atmoſphere, and in that Vehicle to affect human Health.

The great Source of almoſt all theſe Subſtances is *Volcanos*; preceding, and during the Eruption of which, the Air has been ſo affected as to poiſon Birds and other Animals, in the Vicinity of theſe grand and wonderful Appearances of Nature.

The ſecond general Source is, the Practice of various *mechanical Arts*, by which a Variety of Subſtances, poiſonous or hurtful to animal and vegetable Life, are mixed with the Air of the Atmoſphere. We have Examples of this Fact in Derbyſhire, where the Air is impregnated to ſo great a Degree, with various foſſil Subſtances, but principally with Calx of Lead, near the Furnaces for ſmelting the Ores of Lead, that Vegetables are either deſtroyed, or grow near them in a weak and ſickly Manner.

But the Effects of theſe Agents, in contaminating the Atmoſphere, by mixing therewith various Bodies, are not extenſive, and only prove noxious to Life and Health near the Place of their Separation; for they are at greater Diſtances, either depoſited by their Gravity upon the Surface of the Earth, or are abſorbed by Water; or elſe they are ſo diluted, by being diffuſed through a large Part of the Atmoſphere, as to be innocent in their Conſequences.

It has been rendered extremely probable, if it be not demonſtrable, that there are various Species of *Animals* which have their Birth, and which grow and live *in the Atmoſphere* of particular Regions; but the Effects of theſe animated Beings, Natives and Inhabitants of the Air, on human Syſtems, are not known.

But, of all the Subſtances *ſuſpended* in the Atmoſphere yet known, the Properties of thoſe Things which are the efficient Cauſe of epidemic, and many contagious Diſeaſes, *Miaſmata*, are of the greateſt Importance to be underſtood. Theſe *Occaſions* of Diſeaſes, are Subſtances *ſuſpended* in the Atmoſphere, and generated eſpecially in fenny and marſhy Grounds; certain Soils, under particular Circumſtances of Moiſture; Rivers, when exhauſted of a great Part of their natural Quantity of Water; and by the Putrefaction of animal or vegetable Subſtances, in which is comprehended foul or confined Air, accompanied with peculiar Circumſtances.

Theſe *Miaſmata*, which have the above-mentioned Origin, occaſion intermittent, and various Species of continued Fevers, the Plague, &c. but we do not know more of the Properties of theſe Subſtances, than their *Source* and *Effects in producing Diſeaſes*; for we are ignorant whether they be Solids, Fluids, or permanent Vapours; nor are we acquainted with their Taſte, Smell, Colour, or, in ſhort, with any Part of their chymical Hiſtory. It is probable their Bulk is not ſo great, as that their Exiſtence in any Part of the Atmoſphere may be diſcovered by the Teſt of nitrous Gas; and hence, as before obſerved, Air containing an unuſually ſmall Portion of all extraneous Matters, excepting thoſe we are treating of, would not, on that Account, require leſs nitrous Gas to ſaturate it, but Air of an Atmoſphere innocent in its Effects, containing a larger Quantity of *the Air united with Phlogiſton*, and other extraneous Matters, would be ſaturated by a ſmaller Quantity of nitrous Gas: Therefore, by the Effects of this Teſt, as hitherto mentioned by Obſervers, we ſhould draw falſe Concluſions.

It doth not appear, that the Moor-Land of Derbyſhire begets any efficient Cauſe of Fevers, or other epidemic Diſorders: So that the contagious Diſeaſes which appear in this Country, are either generated by Putrefaction, or they are imported from other Regions. It has been obſerved, by ſeveral Practitioners, that intermittent Fevers in particular, never make their Appearance in the Peake. There is a particular Diſeaſe in this Country called *the Derby-Neck*, but by what efficient Cauſe it is produced, I have not learnt.

It is not improbable, that *Matters ſeparated from Animals and Vegetables in the Performance of their Functions*, may affect the human Frame, when conveyed by the Air of the Atmoſphere, as well as the State of *Electricity* of the ambient Air; and alſo ſome *phoſphoric Vapours*; but the Effects of theſe Subſtances on livings Animals have not been inveſtigated, and therefore we can make no practical Inferences.

Moreover *Light*, whether conſidered as an *Emanation*, or as a *Vibration* of an ethereal Subſtance excited by the Sun, is not produced in ſuch *Quantity* in the Peake, as in leſs mountainous Countries in the ſame Latitude, on Account of the State of the Air of this Region above-deſcribed. But of the Effects of this Subſtance or Property on Health or diſeaſed Habits, we have no Obſervations.

CHAP. V.

The Quantity, Frequency, and Form of Water paſſing through the Atmoſphere to the Surface of the Earth.

THE uniform Obſervation of Perſons who have reſided in the Peake, as well as the Inference that naturally follows concerning mountainous Regions is, *that a much greater Quantity of Rain, and alſo Snow, falls in this Country, than in the leſs elevated Lands adjacent.*

About Buxton, and, I imagine, alſo in the other Parts of the high Peake, in the Summer Months, it is common to have an inceſſant Fall of *Rain* for many Weeks ſucceſſively; but about Matlock, where the Moorland is of much leſs Altitude than the Part juſt mentioned, I am told, this Appearance never, or very rarely happens. This Fact is worthy of particular Attention. During the Summer Months, if there are not inceſſant Rains for many Weeks together, there are many rainy Days, and very frequent Showers, in the whole Peake: About Buxton, in particular, there is, in this Seaſon, ſcarcely a ſhowerleſs Day. For the moſt Part, theſe Showers are ſudden in their Appearance, oftentimes ſcarcely announced by a previous Obſcurity of the Heavens, and are as ſuddenly ſucceeded by a ſerene Sky.

Much Water is precipitated alſo in the Form of *Fogs* or *Miſts*. In a Summer-Morning, particularly, the Summits of the Hills are ſeen to *reek*, as it were, with Fogs, exactly like the Smoke from a large Fire aſcending out of a Chimney.

In the Winter and the Spring-Months there is a conſiderable Quantity of *Snow*, far exceeding both in Quantity and in the Time it remains upon the Earth in that Form, that which falls on the neighbouring leſs elevated Land.

Water alſo falls very frequently in the eſtival and autumnal Months, as well as in other Seaſons, in the Form of *Hail*.

The peculiar Occaſion of theſe Appearances may be readily underſtood, by applying the Principles laid down to explain the Humidity of the Atmoſphere of the Peake, p. 123, 144.

When the Water falls in a *fluid State* in continued Rains, or Showers; or in a *ſolid* and *cryſtallized State* in Snow and Hail, the humid Air ſaturated with Water wafted into the Peake, is rarified, and alſo cooled to ſuch a Degree, as to occaſion a more copious Precipitation than happened in order to produce moiſt Air; ſo that the Particles of Water unite in Maſſes capable of paſſing through the Atmoſphere to the Earth by their Gravity, in Oppoſition to the Attraction of Coheſion, or Viſcidity of the Air. If the Temperature of the Atmoſphere when the Water is precipitated, and through which it paſſes, be not of leſs Heat than about 32° Degrees of Fah. Ther. it falls in a *fluid State*, or it rains; but in leſs than that Heat it is a *cryſtallized Solid*, and is precipitated in the Form of Snow.

Hail is ſuppoſed to be Snow rendered partially fluid in its Paſſage to the Earth, and ſeveral Maſſes of this partially melted Snow, united again, rendered ſolid, and cryſtallized in a different Form.

Dew is occaſioned by the Earth, heated by the Sun after a Summer's Day, evaporating Water; which from the Coolneſs of the Evening Air, and in the Night, is only ſuſpended; and in ſuch Quantity as occaſions the Particles to unite, and fall to the Earth.

The *Reeking* of the Summits of the Hills, is owing to the Evaporation of Water, from particular moiſt or wet Spots upon their Tops, into the incumbent cool, and rare Air, by which it is condenſed into a Column of Fog, that diſappears a few Hours after Sun-riſe, by the Air being then ſufficiently heated to diſſolve the Water that evaporated from the wet Places.

The Reader will not be at a Loſs to account for the Manner in which ſo large a Quantity of Water precipitated from the Atmoſphere is diſpoſed of, when he recollects, that it gives Riſe in this, and other Parts of the Engliſh Appennine, to almoſt all the Rivers that flow into the Iriſh Sea on one Side of it, and the German Ocean on the other. *One of the chief Uſes of this Ridge of high Land ſeemingly is, to precipitate Water from the Air blown over the Iſland, for the Utility of the adjacent leſs elevated Regions.*

Practitioners in directing Patients to live in certain Climates, will find it neceſſary to conſider the Influence ariſing from long continued or daily Precipitations of Water. Water contained in the Atmoſphere in a *ſuſpended State*, and alſo Water frequently falling through the Atmoſphere in a *fluid Form* to the Surface of the Earth, will have the Effect of uniting with Gas diffuſed through the common Air; and conſequently, from the frequent humid States, and almoſt daily Precipitations of Water in Rain, we may juſtly conclude, the atmoſpheric Air of this Region to be more free of Impurity ariſing from Gas contained therein in a State of Suſpenſion, than in Countries where contrary States of the Atmoſphere prevail. Moreover, Water will combine with or waſh off almoſt every Kind of Subſtance *ſuſpended* in the Atmoſphere, excepting Water; ſo that, on this Account, we ſhould expect to find *the Moor-Land Air of this Region void of almoſt all extraneous Subſtances, excepting Water*; a Circumſtance never before, as far as I know, ſuggeſted.

CHAP. VI.

The Motion of the Atmoſphere.

THE continued Rains, or the rainy and ſhowery Days, and the alternate clear and dark Skies, in the Peake, are commonly preceded and accompanied by *Wind.*

We want Obſervations to inſtruct us, from what particular Points of the Compaſs the Winds blow at particular Times; and what may be their Duration, Succeſſion, and Degree.

Winds accompanying or preceding the continued Rains, and rainy Days, proceed, in all Probability, from the general Cauſes of Winds of this Iſland; but the Winds preceding and attending the ſudden Precipitations of Water from ſmall Portions of the Atmoſphere, probably blow from all Points of the Compaſs, and ariſe from local Cauſes.

The frequent Winds along with Showers, are generally ſudden in their Appearance, and blow with great Briſkneſs or Violence; ſo that they are often *Guſts* and *Storms,* that before, or with, the ceaſing of the Showers, are ſucceeded by Calms, and ſerene Weather.

The Atmoſphere of the Peake then, is with ſome Degree of Conſtancy, either well ventilated by Currents of Air, from the ſubjacent Lands and Seas, or by partial Motions of the Air, from Cauſes ſubſiſting within this Region of high Land.

The Effects of the Winds, or Agitation of the Atmoſphere, have been much noticed by the moſt antient Writers, eſpecially by thoſe who have written upon peſtilential Diſeaſes.

Some Winds are obſerved to excite epidemic and contagious Diſeaſes; others, to interrupt or diſpel them. The large Fires in the open Air, employed (*l*) ſo frequently in Times of contagious Diſeaſes, to prevent their Progreſs, appear to have that Effect, by exciting an artificial Wind, rather than by any Thing added to, or deſtroyed in the Atmoſphere, during the burning of Subſtances.

It may at firſt Sight appear, that as much Miſchief may be done as is removed by blowing Weather; but the Winds, which are the Vehicle of the *Occaſions* of Diſeaſes, can ſcarcely be claſſed among thoſe briſk Winds, which blow ſo frequently in mountainous Regions, nor are they accompanied with ſuch Quantities of Rain; therefore it may be inferred, that *the Winds, by diffuſing any noxious Subſtances, whether they be Solids, Fluids, or permanent Vapours, through the general Maſs of the*

(*l*) " *Hippocrates*, cum ab Illyria peſtis Græcis immineret, accenſis Sylvis eam avertit, qua de Cauſa Græcia ei ſtatuam pileo capite tecto locavit æqualeſque cum *Hercule Hippocrati* Honores decrevit, quod ceu alter *Hercules* Monſtrorum Domitor, peſtem à Græcia averterit."—*Sennertus.*

Atmoſphere; *as well as Rain*, *by waſhing them off, combining with, or, perhaps, decompoſing them, render the Atmoſphere of the Peake more pure or free from extraneous Subſtances, than the leſs elevated Countries*; and conſequently, the Phyſician will have *a Ground for his Conduct in the Treatment of Diſeaſes, founded upon the Conſideration of the Purity of the Air of this Region, ariſing from theſe Circumſtances.*

We have now ſtated the particular Properties of the Atmoſphere of *the Southern Extremity of the Britiſh Appennine*, or the Moor-Land of Derbyſhire, with the View of diſtinguiſhing the Effects of Buxton-Water from thoſe of the Atmoſphere; and of furniſhing Practitioners with a better Foundation for Practice, than mere Conjecture.

Further Grounds of Practice might have been obtained, by *a Hiſtory of the Health of the Natives of the Peake*, viz. their Form; the peculiar State of the Functions of the Body and Mind; their Fecundity; Diſeaſes; Duration of Life, &c. But a farther Proſecution of this Subject, was not conſiſtent with my other Engagements. I muſt not omit, that it is a general Opinion, that the Air of this Part of Derbyſhire is favourable to long Life; but whether the Fact upon Enquiry would be, an unuſual Number of People who have lived to great Ages, I have not been able to learn. If, however, this ſhould prove to be the Truth, the Inference would not be fair, that the

Lives of Natives of different Regions might be protracted, by tranſporting themſelves into this Country. It is found, that the Atmoſphere in which a Perſon is born, of whatever Nature it be, is often capable of reſtoring Health, that is, enjoyed indifferently, in what are reckoned more ſalubrious Climates:

" ————————Cuſtom moulds
" To ev'ry Clime the ſoft Promethean Clay:
" And he who firſt the Fogs of Eſſex breath'd,
" (So kind is native Air) may in the Fens
" Of Eſſex, from inveterate Ills revive,
" At pure Montpelier or Bermuda caught."

ARMSTRONG.

It is alſo an Obſervation made by the Antients, and which has been found by Phyſicians in ſubſequent Ages to be perfectly juſt, that *Change of Climate* (*m*) is favourable to the Reſtoration of Health, independent of any Conſiderations with Reſpect to the different ſalubrious Qualities of the Atmoſphere of various Regions; and as the Atmoſphere of the Peake is, on many Accounts, very different in its Properties from almoſt all other Countries of this Iſland, a Removal into it may be, on this Ground, very frequently a Means of removing Diſeaſes.

(*m*) " Peſſimum ægro eſt Cœlum, quod ægrum fecit; adeo ut in id quoque Genus, quod Naturâ pejus eſt, in hoc ſtatu Salubris Mutatio ſit."—*Celſus.*

The Inferences I have made from the preceding Hiſtories are but few, becauſe the Limits of this Work did not admit them: and I rather chuſe each Phyſician to make the Application his own Judgment ſuggeſts, than to be liberal of my own practical Deciſions.

I ſhall juſt point out further, that in forming a Judgment of the Application of the Mountain-Air of the Peake, not only *the Effect of its particular Properties ſhould be conſidered ſingly, but of the whole in Conjunction.*

Being now inſtructed in ſome Knowledge of the external Form, and internal Structure and Properties of the Earth, we ſhall be better qualified to attempt the ſecond Part of this Work,

PART II.

HISTORY OF THE CHYMICAL QUALITIES OF THE TEPID WATERS OF BUXTON.

SECTION I.

Of the Properties of the tepid Waters of Buxton, that are diſcovered immediately by the external Senſes, and of their Temperature and ſpecific Gravity, as they appear experimentally. To which is premiſed, a Deſcription of the external Form of the Country, and of the Structure and Contents of the Earth, at and environing Buxton; alſo, various Particulars relating to the Number and Situation of theſe tepid Springs.

THE tepid Springs of Buxton ariſe out of the Earth in a Vale, environed by hilly, or more properly, uneven wavy Land; on the South Side of the Rivulet *Wye*, within the Diſtance of forty or fifty Yards from each other, and about half a Mile from the Source of this Rivulet; or, perhaps, more accurately ſpeaking, of the Part where it burſts from the natural ſubterraneous Paſſage that conveys it from *Ax-Edge* to this Vale.

The uppermoſt Stratum on the South Side of the above Rivulet is the *firſt*, or *black Lime-Stone*;

Stone; which has been burnt, Time immemorially, to Quick-Lime, on an adjacent Hill, as appears from the large Groupe of whitiſh conical Heaps of Lime-Stone-Kilns, and Rubbiſh, left after burning this Stone to Quick-Lime.

This Stratum is covered in ſome Parts with Fragments of Shale, of a few Feet in Thickneſs, and perhaps, alſo, by the Clay of which Bricks are made in the above Vale.

On the North Side of this Rivulet, the ſuperior Stratum is firſt *Shale*, but after aſcending towards the Summit of the Hill on this Side the *Wye*, it is *Grit-Stone*, incumbent on this Shale and the other Strata before fully deſcribed, that conſtitute " the Cruſt of the Earth" in the Peake.

The looſe Stones in the Rivulet in this Part of the Vale, are chiefly rounded or broken Maſſes of Iron-Stone, ſome of which are entitled to the Appellation of Iron-Ores. It appears, that the Earth for a ſhort Diſtance on each Side, and under the *Wye* at Buxton, does not conſiſt of the above-deſcribed Strata on each Side of this Rivulet, but is compoſed of looſe Maſſes of Stone, which are ſeemingly Part of the Strata natural to this Region broken to Pieces: So that the Strata on each Side of the Wye, or Vale through which it runs, are ſeparated from each other by, apparently, a Chaſm that has extended nearly through the Middle of this Vale filled up with fractured or looſe Maſſes of Stone, called *Rubble*; over which Chaſm the Rivulet flows, and upon which the new Building, the *Creſcent*, and other Houſes are erected.

The Deficiency of the Stratum of Grit-Stone and Shale on the South Side of the Wye, and their Appearance on the North Side of this Rivulet, indicate, that a Fracture of the Earth has here happened, which has removed the two ſuperior Strata in one Part. The original or horizontal Poſition of theſe Strata has been alſo changed; for on digging into the Earth, the inclined Poſition of the Strata has been obſerved;—on the South Side they are ſo conſiderably inclined, that at about a Mile South of Buxton on the Aſhburne Road, the firſt Toad-Stone *baſſets* or becomes the moſt ſuperior Stratum; and were the Rubble that now fills up the Chaſm in this Vale removed, and the Strata on each Side of it brought into Contact with each other, the firſt Lime-Stone on the South Side of the Wye would touch the Stratum of Shale on the oppoſite Side; and the firſt Toad-Stone on the South Side, would be in Contact with the firſt Lime-Stone of the North Side. As Part of the Stratum of Grit-Stone is wanting immediately on the North Side of the Rivulet at Buxton, the uppermoſt Stratum to a certain Diſtance from the Rivulet on the North Side is Shale, after which towards the Summit of the Mountain it is Grit-Stone. See Plate I.

The Soil of the Land in this Vale is barren, but cultivated for Paſturage and Hay; is woodleſs, and fenced with Walls of Lime-Stone.

The Aſpect of this Region, from the Summits of the ſurrounding or contiguous Hills, is an extenſive Tract of wavy Moor-Land without Trees, Shrubs, or Fences, excepting ſome blackiſh Stone Walls in a few Parts; and on any of theſe eminent Places, it appears to the Beholder as if the Spot on which he is placed were environed with a Chain of hilly Land: So that the Face of Nature is as dreary and joyleſs in this, as in moſt other Parts of the Peake.

If we accompany the Rivulet Wye in its winding Courſe in a pebbled Channel for a few Miles, we paſs through Vales, not unfruitful in Herbs for Paſturage, between Cliffs among Lime-Stone Rocks, or through *Ravines* partially cloathed with various Shrubs and Trees of the Foreſt, ſo as to afford a Diverſity of agreeable and romantic Pieces of Scenery. There is at preſent no Road through the Tract I am deſcribing, but with no great Labour a Path might be made for two Horſes to travel abreaſt; and, after conſulting the Genius of the Place, a Man of Taſte might, without conſiderable Expence, compoſe natural Scenes far more pleaſing than the preſent State of Nature affords. A Work of this Kind has been in Contemplation, but is not likely to be ſoon executed, although it would be of obvious Advantage to thoſe who repair to Buxton for the Reſtoration of their Health, and alſo be profitable to the Owners of Eſtates.

The only Conſolation to the Invalid in his Airings at Buxton is, at preſent, that of breathing pure Air, and travelling on good Roads. The Countenance of Nature here being naturally gloomy, it excites in many Conſtitutions very unpleaſing Senſations. This Climate is, indeed, execrable on this Account to the unhappy Hypochondriac. As it will ſcarcely be doubted, that the good Effects of Exerciſe are much increaſed when accompanied with pleaſing Scenes of Nature, it is greatly deſiderated to render the Aſpect of the Country near Buxton agreeable, or to make it at leaſt leſs gloomy and uncomfortable. The Means of attaining ſo deſirable an End, are not ſo difficult as may at firſt be imagined.—I have purpoſely ſaid more upon this Subject, on Account of the Cultivation and ornamenting of the neighbouring Grounds, bearing ſo inconſiderable a Proportion to the various Kinds of convenient and agreeable Accommodation for the Reception of Viſitors to Buxton.

The Riſe of the River Wye near Buxton, or more properly its firſt Appearance after flowing through a natural ſubterraneous Paſſage from Ax-Edge, its Courſe to the Derwent at Rowſley, and, in Conjunction with this and other Rivers, to Matlock, denote *the ſuperior Altitude of this*

Part of the Peake to that of Matlock, and the other Tracts of high Land through which it runs (*n*).

The tepid Springs of Buxton iſſue out of the Bowels of the Earth, either through Fiſſures in the Lime-Stone upon the Surface, or from the *Rubble* covering ſome Part of this Stratum.

Several of theſe ſupply new Saint Anne's Well in the ſame Manner deſcribed Page 9 (*o*).

On inſpecting the Bath, called the *Gentleman's Bath*, when emptied, it appeared that it was ſupplied, principally, by the Water iſſuing from one or two Fiſſures in the Lime-Stone Stratum at the South-Eaſt Side of the Bath, where it is not paved. It is alſo uſually reckoned, that ſeveral ſmall Springs ooze through the Seams of the flat Stones of the Floor of this Bath.

Theſe Springs are ſaid to fill the Bath to its ordinary Depth, or about five Feet, in 50 Minutes. It was two Hours and 50 Minutes before this Bath

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(*n*) The Mountain Ax-Edge, in which is the Source of the *Dove* and *Wye*, is about 1100 Feet above the Level of the Ground at Buxton-Hall; and Buxton-Hall is 1000 Feet or thereabouts higher than Derby: So that the Column of Quickſilver in the Barometer-Tube is always one Inch lower at Buxton than at Derby, at the ſame Time and under ſimilar Circumſtances. For this Fact I am obliged to my Friend Mr. Whitehurſt, who made the Obſervations which aſcertained it.

(*o*) According to Dr. Short's Obſervations and Calculation, theſe Springs throw out 390 Gallons of Water in an Hour. P. 4. of Dr. *Short's* Work.

was filled by its Springs, according to my Obſervation; but during this Time they flowed alſo into the two adjoining Baths, neither of which contains ſo much Water as the Gentleman's Bath. This Bath meaſured 25 Feet 6 Inches in Length, 12 Feet 8 Inches in Breadth, and the average Depth was 4 Feet 10 Inches, therefore it contained 2,697,696 cubic Inches, and 9,566 $\frac{84}{282}$ Ale Gallons of Water.

Some calculate, that theſe Springs throw out Water at the Rate of 60 Gallons a Minute.

If we ſuppoſe two and a half Times the Quantity of Water I found to be contained in the Gentleman's Bath, to have flowed into the three Baths in the two Hours and fifty Minutes I obſerved it required to fill one of theſe Baths; then the whole Quantity flowing from theſe Springs in the above Time, was about 23,916 Ale Gallons, or about 8,440 hourly, and nearly 140 Ale Gallons a Minute. Perhaps, however, I might be as near the Truth, by ſuppoſing only twice the Quantity found to be contained in the Gentleman's Bath, to have flowed into the three Baths in two Hours and fifty Minutes, for the above Quantity of two and a half Times its Bulk, is, I ſuſpect, too great.

Beſides the Gentleman's Bath, there is a *Bath for the Ladies*, and a *Bath for the Uſe of the Poor*; which are ſupplied by ſmall Streams that flow through the Seams of the Pavement of each of them.

Theſe are the only Branches of the tepid Spring now in Uſe, and many of them are obſerved to riſe *perpendicularly* out of the Earth. The other tepid Streams, which were probably never made uſe of, are concealed from View naturally, or by Art; and are, chiefly, in the Earth between the *Hall* and the *Creſcent*; alſo, under the South-Weſt End of this laſt Building, and perhaps to a greater Diſtance Eaſtward of the *Hall.*

Tepid Water was raiſed two or three Years ago, by a Pump placed againſt the Outſide of the Hall, upon the Foot-Road leading from the Hall to the Well, and was drank during the Time of making the Alterations in the Situation of the Well; but it is now diſuſed.

This Water was not from a ſeparate Spring, as ſome affirmed, but from the Spring which ſupplies the Bath before it breaks through the Fiſſure of the Rock in the *Gentleman's Bath.*

Bingham, or *Leigh*'s *Well*, formerly in Uſe, is now, I believe, covered by ſome Work-Shops, erected for the Convenience of carrying forward the Building of the Creſcent.

There are many *cold Springs* on the South Side of the Rivulet *Wye*, in the Vale near where the Streams of the tepid Springs riſe, and even in the Spaces of Land between them.

Alſo, about half a Mile South-Weſt of the *Hall*, in the ſame Vale, there is a Spring of a much greater Heat than that of the cold Springs of this or other Regions in general; and from which a *permanent Vapour* ſeparates itſelf in the ſame Manner, and of the ſame Kind, as that of the tepid Springs near the *Hall* at Buxton; excepting upon one Occaſion, when I found it was mixed with Air.

At this Spring-Head in the Summer 1782, not having with me a proper Inſtrument for meaſuring permanent Vapours, I mixed about an Ounce Meaſure of the Bubbles that ariſe ſpontaneouſly from this Spring, with an equal Bulk of nitrous Gas, in a four Ounce Bottle. The Mixture was at firſt turbid, and, upon Agitation, Water roſe evidently above the Mark denoting two of theſe Meaſures mixt together; but upon a Repetition of this Experiment with an Eudiometer, no turbid Appearance or Diminution of Bulk of the two Meaſures were obſerved. This Spring would very probably be of the ſame Temperature, and have the ſame Properties as the other tepid Springs, could they be procured without an Admixture with the contiguous cold Springs.

The above-mentioned cold Springs are all, or moſt of them, hard Waters; are not petrifying, and are without Taſte, Colour, or Smell. I neglected to enquire whether they depoſit Earth, copiouſly, like the tepid Waters of Buxton, in boiling. Their Temperature, aſcertained by two Thermometers, graduated with Fahrenheit's Scale, between the Hours of 8 and 10 A. M. when the Heat of the Atmoſphere was 54° to 57°, was as follows.

The Cold Spring near the Angel-Inn	47° ½,
— Pump-Water adjoining St. Anne's Well	49°,
— Cold Springs in the Meadows South-Weſt of the *Hall* —	47° to 49°,
— Rivulet Wye about 50 Yards from its Source — —	49° ½,
— Ditto, at Fairfield Bridge —	51°,
— Cold Spring, adjoining to, and mixed with, the tepid Spring, half a Mile South-Weſt of the *Hall* at Buxton, in a Meadow belonging to Dr. Norton, of Macclesfield; Temperature according to the Part examined	50° to 55°,
— *Tepid Spring*, into which a Part of the laſt mentioned Spring flowed	63° to 64°,
— Cold Springs and petrifying Springs a few Miles from Buxton —	48° to 49°.

On the North Side of the Rivulet, near the Bridge at Buxton, there is a cold Spring, which contains *Iron* diſſolved by *vitriolic Acid*, that decompoſes ſpontaneouſly upon Expoſure to the Air, and therefore it tinges the Baſon in which it is received of a browniſh Colour. The Temperature of this Spring was various, according to the State of the Air, becauſe a Quantity of it is expoſed to the Influence of the Heat of the Atmoſphere, after it ſprings out of the Ground: Its Heat varied from 52° to 55°. This Spring iſſues from the Stratum of Shale, and has been already mentioned in a former Part of this Work, as an Inſtance of this Stratum abounding with chalybeate Springs.

In order to convey to my Readers more fully and clearly the Knowledge of the internal Structure and Contents of the Earth at Buxton whence the tepid Springs riſe, I have inſerted the following accurate Repreſentation of the Strata at this Place, engraved from a Drawing with which I was favoured by my ingenious and worthy Friend Mr. Whitehurſt, for which I acknowledge myſelf greatly beholden to him. I experience great Satisfaction in giving this Plate to the Public, not only becauſe it is capable of communicating more juſt and compleat Ideas of the ſubterraneous Geography of this Country than could be conveyed by Words, but becauſe it affords an Example of the interior State of the Earth throughout the whole Peake, and perhaps throughout the whole Anglo-Appennine; and which will therefore be an excellent Illuſtration of the Deſcription of the Structure and Contents of the Earth of the Peake, given Sect. V. p. 34. and Sect. VI. p. 43. of this Work.

EXPLANATION OF PLATE I.

1. Grit-Stone, 120 Yards in Thickneſs.
2. Shale, 120 Yards thick.
3. Firſt Lime-Stone, 50 Yards in Thickneſs.
4. Firſt Toad-Stone, 16 Yards thick.
5. Second Lime-Stone, in Thickneſs 50 Yards.
6. Second Toad-Stone, 46 Yards thick.
7. Third Lime-Stone, 60 Yards.
8. The Part of the Earth that conſiſts of *Rubble*, which appears to be Fragments of the Strata 1, 2, 3, 4, &c. on each Side of it. In this Part the Earth has probably been rent, and a Chaſm formed, which has been filled up with Pieces of the Strata broken to Pieces.

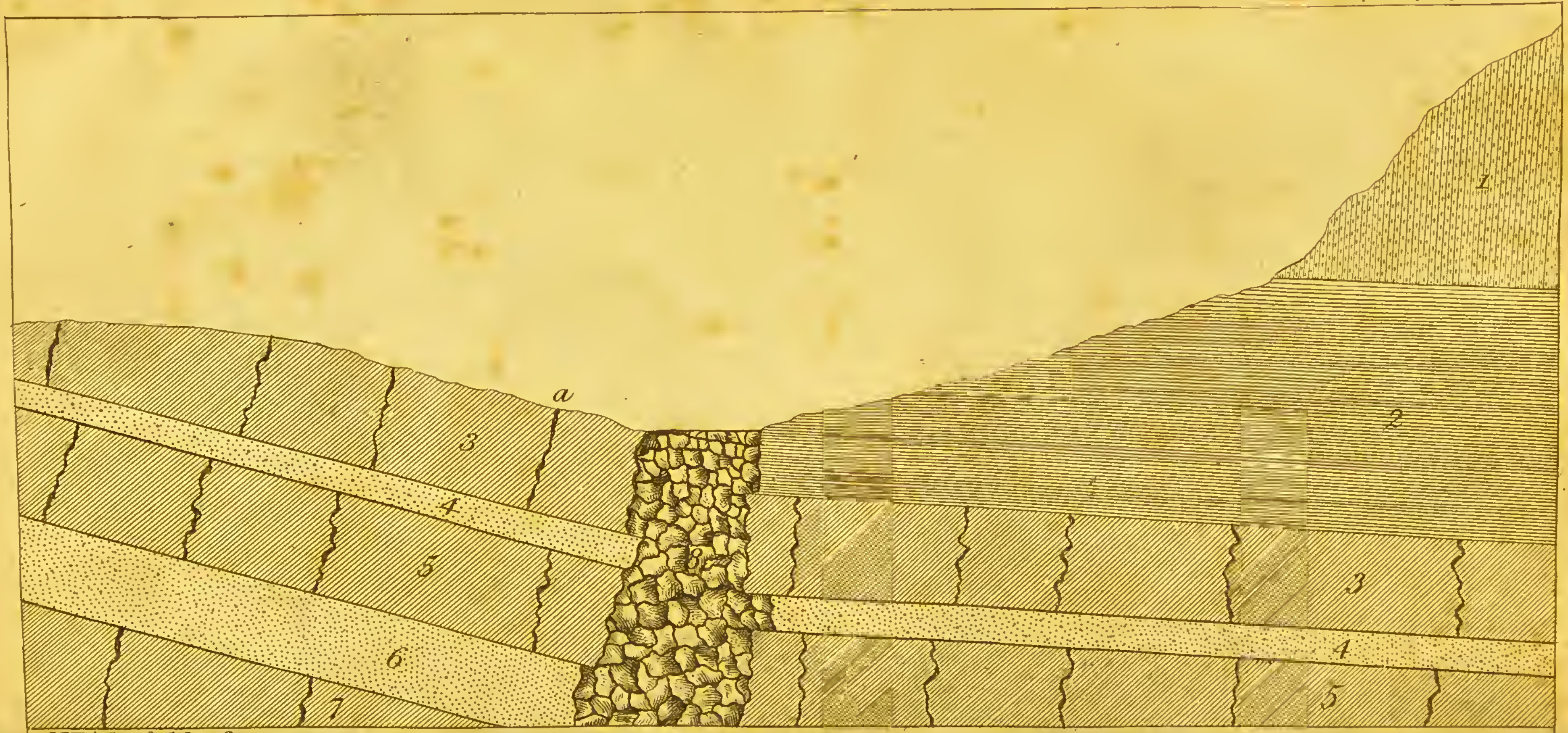
a. The Situation of the tepid Springs, and Manner in which they may be conceived to riſe out of the Earth from the Toad-Stone Strata, perpendicularly through the Lime-Stone Beds.

As the Properties of the tepid Springs of Buxton are all, apparently, preciſely the ſame, the Hiſtory of one of them may be conſidered as an Example of any of the reſt.

When this tepid Water is taken freſh from the Spring, and viewed in a Glaſs-Veſſel, it is of a *cryſtalline Tranſparency* and *colourleſs*: Alſo when a large Bulk of it is viewed together, as that contained in the Baths, where it is four or five Feet in Depth, it is *colourleſs*, and refracts the

Rays

to Front p.150 Vol.I.



J. Whitehurſt del. 1784.

Rays of Light ſo little that Objects may be ſeen through it of their cuſtomary Appearance, provided it be in a State of Reſt.

However, when the Bath is agitated, as by the plunging of Bathers, it is inſtantly changed from a State of Tranſparency to that of *Turbidneſs*; but as ſoon as the Commotion ſubſides, it becomes inſtantly clear as before. This turbid Appearance has been miſtaken for Filth depoſited on the Pavement of the Bath, and ſtirred up and mixed with the Water; but it certainly is not occaſioned by this Circumſtance, becauſe it may be produced at all Times, even immediately after the Bath has been waſhed clean, and when there is no Sediment to be obſerved in the Bath. Moreover, Glaſs Veſſels were filled with this ſeemingly muddy Water, and it appeared perfectly clear; nor did it depoſit any Sediment on ſtanding.

A little Attention readily ſuggeſted an Explanation of this Phenomenon. The Rays of Light enter the Bath Room through a Window near the Top of it, and paſs through the Air of the Room, and alſo through the Water, when in a State of Reſt, without ſuffering any conſiderable Inflection in their Paſſage from the rarer into the denſer Medium, therefore produce no Colour: But when the Water is agitated, and its Parts or Portions of it are moved with Rapidity againſt each other in a Variety of Directions, the Rays are broken into numberleſs Parts, and variouſly inflected upon the Surface of, and within the Water; by which Means Rays of all Colours are occaſioned, viz. red, yellow, and blue; which, being blended together, reflect the whitiſh or grey Colour of the Water; as ſoon as the Commotion ſubſides, the Rays of Light paſs through the Water as before, without any conſiderable Refraction, and therefore the Bath reſumes its Tranſparency. This Phenomenon is then a mere *Deceptio Viſus.*

Some have aſſerted in Converſation, that this tepid Water is of a bluiſh Caſt; and have mentioned this Property to ſhow, that it contained Copper; but I am confident, there is no Subſtance in this Water occaſioning any Colour; and whenever it has reflected any coloured Rays, they have depended upon ſome Circumſtances variouſly refracting them, independent of any Impregnation of this Fluid.

This cryſtalline Fluid contained in Veſſels, commonly immediately after being drawn from the Spring, and always on ſtanding in a temperate Heat of the Atmoſphere, exhibits *bright Bubbles*, apparently of ſome permanent Vapour, of the Size of the ſmalleſt Pin's Head, adhering to the Sides of the Veſſel, or whatever is immerſed in it.

The Baths contain theſe Bubbles in every Part of them, eſpecially upon a little Agitation. Moreover, *Streams* or *Cluſters* of theſe Bubbles, of various Sizes, from the Magnitude of the ſmalleſt Pin's Head to the Bulk of a Cherry, or even ſometimes of a Billiard Ball, every now and then break out from the ſmall Holes and Vacuities between the Stones that compoſe the Pavement of the Baths, and dart perpendicularly upwards through the whole Thickneſs of the Water to its Surface, where they burſt and vaniſh in the Atmoſphere.

Theſe Bubbles alſo adhere frequently to the Skin of Perſons bathing, where they excite a prurient Senſation.

If the Bubbles that adhere to Veſſels containing this Water after ſtanding, be ſhook off, a freſh ſet of them will collect on further ſtanding; which may be detached as the former, and in this Manner do they collect for ſeveral Times: But after a certain Number of theſe Particles have thus ſeparated themſelves, the Portion of Water that yielded them will manifeſt them no further, however long it be left to ſtand in the ſame Temperature of the Atmoſphere as on its firſt Expoſure.

But in a Portion of Water that has ceaſed to manifeſt Bubbles in a temperate Heat, by expoſing it to greater Degrees of Heat, they will again appear; and after detaching a certain Quantity, however long the Heat be applied, no more can be procured.

I am not certain, if this Water does not become *leſs tranſparent* by ſtanding in open or cloſed Veſſels, in temperate Degrees of Heat of the Atmoſphere; but no Sediment can be perceived to be thereby depoſited; nor does it depoſit any Earth, where it runs in its accuſtomed Channels upon the Surface of the Ground.

The Bath-Rooms are obſerved, I believe, at all Seaſons, to be filled with *Steam*, provided the Doors have been ſhut ſome Time before, but in greater Quantity in cold than warm Weather.

Frequently a Stratum of *Steam* is incumbent upon the Well; which Appearance is obſerved commonly at all Seaſons early in the Morning, or late in the Evening; generally at all Times of the Day and Night when the Weather is cool; and always when the Air feels cold, or when very moiſt; but moſt copiouſly when Cold and Moiſture of the Atmoſphere are conjoined, and when the Air is ſufficiently cold to congeal Water. When the Steam is obſerved to ſit upon the Well in the Day-Time in temperate Weather, it has been found to be a pretty certain Forerunner of Rain at Buxton, or in its Neighbourhood.

I have never perceived any *Smell* from this Fluid; nor will it become fetid by ſtanding, as ſome have aſſerted, in any Degree of Heat, provided the Veſſels in which it is preſerved be perfectly free from extraneous Subſtances; but if a minute Portion of animal or vegetable Matter, as a Portion of Cork or Shred of Bladder, be mixed therewith, it will, like other Spring-Water, acquire a fetid Smell after a certain Time. Water is a fermentable Subſtance with $\frac{1}{500}$ of its Weight of animal or vegetable Matter; and on this Account the Thames, and ſome other River-Waters, undergo the putrefactive Fermentation.

Buxton-Water is perfectly *inſipid*; in particular, it has not the ſlighteſt *acidulous Taſte*, but it is rather *warm* to the Palate; at leaſt it is much *leſs cool* than ordinary Spring-Water.

This Water feels rather *hard* or rough when rubbed between the Hands and Fingers, like ordinary hard Waters that decompoſe Soap. When the human Body is immerſed in Buxton-Water, it commonly excites a gentle Shock by the *Senſation of Cold* it produces, which, in a few Seconds, is ſucceeded by a Feeling of agreeable Coolneſs, or of a ſlight Degree of Warmth. It feels warmer in cold Weather, as in Winter, than in warm Seaſons.

It is not more *ſonorous* than common Spring-Water; as appears by pouring it from one Veſſel into another at a Diſtance below it.

The Heat of thoſe Springs of Buxton-Water, as denoted by the Expanſion of Quickſilver in ſeveral Thermometers graduated according to Fahrenheit's Scale, which ſupply the *Gentleman's Bath*, has been obſerved to be 81° ¾ to 82°; and of the *new Saint Anne*'s *Well* 81° to 81° ¼.

There is good Reaſon to believe, that this Water has been of preciſely the ſame Temperature for many hundred, perhaps many thouſand Years. It has certainly been of the ſame Heat, ſince this Property was aſcertained by the Uſe of Thermometers more than thirty Years ago. There has been indeed a Variation of about one Degree of Fahrenheit's Scale, in the Accounts given by different Perſons of ſufficient Accuracy for aſcertaining this Point; but that Difference was not occaſioned by the Variation of the Heat of the Water, but was owing to the Difference of the Thermometers employed: For there is liable to be a Want of preciſe Conformity in the Degrees of Expanſion, as denoted by the Scale, between different Inſtruments expoſed at the ſame Time to the ſame Temperature; if not in all the Degrees, at leaſt in ſome of them.

The ſmall Difference between the Heat of the *Well* and the *Bath*, is occaſioned by the former being expoſed to the Atmoſphere, which being always much colder than the Water, receives ſome of its Heat; but the latter, being expoſed to the Air of the Bath-Room, the Temperature of which is only ſix or eight Degrees colder than the Water, receives leſs Heat from it than the open Air does from the Well.

For ſome Time after the Alteration in the Situation of the Baſin, or of the *Well*, as it is commonly called, already mentioned, p. 11, the Water was found to be colder than it was in the former Baſin, named *old* St. Anne's Well; it was at firſt ſeveral Degrees and afterwards about one Degree, of Fahrenheit's Thermometer, of leſs Heat than at the *old* Well. A ſatisfactory Reaſon might be aſſigned for this Alteration in the Temperature of the Water in the new Baſin, made for the Convenience of drinking this tepid Spring. In order to make my Readers acquainted with the *Occaſion* of this Diminution of the Heat of Buxton-Water, and with the Means by which it was reſtored to the ſame Temperature as in the *old* St. Anne's Well, as well as to enable them to form a Judgment of the Effect of the late Alterations at Buxton upon the Water, I ſhall ſtate,

Some Facts relative to, with Remarks upon the Circumſtances of, the NEW *and old St. Anne's Well.*

There was no Spring in the old St. Anne's Well, p. 11, as was commonly ſuppoſed. The Receptacle containing the Water was ſupplied from ſubterraneous Streams of the tepid Spring that iſſued from Fiſſures in the Stratum of Lime-Stone, at the Diſtance of many Feet from the Well. When this Well was demoliſhed about four Years ago, for the Purpoſe mentioned in a former Part of this Work, p. 11, the Water was conveyed in a Grit-Stone Channel from the very ſame Streams as before, but in much larger Quantity, perhaps to a greater Diſtance, and in a different Direction.

The Water was conveyed at leaſt forty Feet, in a North-Eaſt Direction, to the *old* Well; and it is now conducted forty-ſix Feet Diſtance, South-Eaſt, in a covered Channel of Grit-Stone, which is of a ſemi-cylindrical Form; the Stones compoſing which lie on their convex Side. The Diameter of the Cylinder, of which this Channel is nearly a Semi-cylinder, is about four Inches and a half.

The Baſin of the new St. Anne's Well is hewn out of one entire Maſs of Grit-Stone, and it is covered with a maſſy Stone of the ſame Kind, placed in Contact with the Water, and cemented down. An Aperture is made in the Side of the Baſin, through which the Water perpetually flows, as from a Pump-ſpout, at the Rate of half a Pint in a Second of Time.

A neat Baſin of white Marble is placed under the Stream that flows through this Aperture, for the Convenience of filling Glaſſes and other Veſſels with this Water.

The Baſin of the *old* St. Anne's Well, being always open, was expoſed to the Danger of being made foul and impure. The Temperature of the Water therein was 81¼ or 81°.

The Occaſion of the Diminution of the Heat of the Water in the *new* Baſin, ſoon after the ſame Streams were conducted into it that ſupplied the *old* Well, will now readily be apprehended. The new Channel and the Earth near it being much colder than Buxton-Water, Heat would be communicated to theſe ſurrounding Bodies from this Water, until they acquired nearly the ſame Temperature as this tepid Spring; conſequently, for ſome Time, it was found of leſs Heat in the *new* Baſin than in the *old* Well. It is obvious, that this Water flowing for a ſufficient Time through this new Channel, would be alone ſufficient to reſtore it to its priſtine Degree of Heat: but to produce this increaſed Degree of Heat ſooner, the Baſin was covered with the Stone Cover; in conſequence of which the Communication of Heat from the Water in the Baſin to the Atmoſphere, was prevented.

The Effect of further Time, and thus intercepting the Communication between the external Air and the Water in the Baſin, was the Appearance of this Spring-Water of its former Heat, namely, 81 ¼ or 81° of Fahrenheit's Thermometer.

From this State of Facts, and the above Remarks, it appears extremely improbable, that the Buxton-Water has ſuffered any Change or Diminution of its medicinal Qualities by the late Alteration in the Situation of the *Baſin*; on the contrary, it is now uſed accompanied with ſome deciſive Advantages, both with Reſpect to its ſalubrious Qualities, and its Mode of Application; which have been produced by the Conſtruction of the new Well.

For, 1. As the medicinal Qualities of this Water chiefly depend upon a *permanent Vapour*, as I ſhall ſhew fully in the Courſe of this Work, of which a great Part is liable to eſcape upon Expoſure to the open Air, the preſent Mode of drinking it, prevents in the moſt effectual Manner the Flight of this Subſtance, which it was liable to in the former Well.

2. The Method now in Uſe, of receiving the Water from a Hole in the Side of the large Grit-Stone Baſin, is far more agreeable than the former Method of immerſing the Hand and Glaſſes, or other Veſſels, in the Well, in order to fill them.

3. The preſent Contrivance of the Channel which conveys the Water to the Baſin, is far more compleat than the former one; and by Means of the Stone Cover over the Baſin, the Water is preſerved free from accidental Impurities, to which it was heretofore liable.

It may be proper to add a few Obſervations, in Order to render the preceding Account of the Circumſtances of the new, and old Well, and of the Manner in which the Water was conducted into them, more compleat and intelligible, as well as to ſhew further the Advantages obtained in conſequence of the late Alterations, with Reſpect to the Manner of conveying the Water to the new Baſin, and the Preſervation of its medicinal Qualities.

Several ſmall ſubterraneous Streams of a tepid Spring are received into a Sort of Reſervoir, in the Earth, at the North-Weſt End of the Grit-

Stone Channel which conveys the Water into the *new* Well. The ſame Streams flow into this ſubterraneous Receptacle as thoſe which were formerly conducted into the *old* Well.

The Streams which are thus collected, have been erroneouſly conſidered to be the Sources of diſtinct Springs, but they are truly Currents or Branches of, probably, only one tepid Spring, with the Source of which we are unacquainted. All the tepid Streams which have been met with in the Vale under or near the *Creſcent* at Buxton, appear to take a northern Courſe; and, perhaps, they are all Streams from the ſame Spring, which is, ſeemingly, in the Bowels of the adjoining Hill, to the South of the *Hall*.

Having made theſe *Remarks*, I ſhall reſume the Account of the Properties of Buxton-Water.

Matlock, Buxton, and common Spring-Water, were expoſed to a freezing Cold of the Atmoſphere under ſimilar Circumſtances:—They all became Ice in the ſame Time; all detached Bubbles which were retained in the Maſs of ſolid Water; thereby increaſing the Bulk of the Water, ſo as to riſe over the Surface, and burſt the Sides of the Phials in which they were contained. Theſe Maſſes of ſolid Water being expoſed to a Temperature of 54° of Fahrenheit's Thermometer became fluid, and, in returning to a State of Fluidity, the Bubbles of Vapour eſcaped. Theſe Waters had not ſuffered any Change, apparently, after being frozen and again rendered fluid, excepting having loſt a Part, at leaſt, of their Vapour; for they have the ſame ſenſible Properties, and precipitated Lime from Lime-Water as copiouſly as before. In one Inſtance, ſome Earth was found depoſited in Matlock-Water, as there appeared a Precipitation in Conſequence of freezing; which is accounted for in general, by ſaying the Water was robbed of Gas, the Menſtruum of the Earth, on being rendered ſolid by Cold, and therefore was precipitated. But no Gas was ſeparated, and it may be accounted for, if this ſhould prove a Fact on Repetition of the Experiment, by ſuppoſing the Water contained more Earth than it could diſſolve in Degrees of Heat in which it was fluid near the freezing Point, and therefore depoſited Part of its Earth. Theſe Waters rendered ſolid, in Conſequence of the ſurrounding Temperature, had, like all other Spring-Water, the Properties of Glaſs, and might be employed for all the Purpoſes of this Subſtance, excepting the Property of being fluid in leſs Degrees of Heat than the Glaſs produced by fuſing certain ſolid Subſtances, viz. for Microſcopes, Burning-Glaſſes, &c.

The *Effects of Heat* on this Water will be related in a different Part of this Work.

The *comparative Gravity* of the Water of theſe tepid Springs, and of ordinary cold Spring-Waters, alſo of Rain and diſtilled Water, was attempted to be found, by weighing each of them with a fine

Balance in the ſame Florence Flaſk, with a narrow Neck, upon the ſtraiteſt Part of which was made a Mark with a Diamond; and by the Veſſel being ſo filled, that the moſt concave Part of the Surface of the Water ſhould be even with the Mark upon the Flaſk, when viewed, as often as filled, exactly in the ſame Poſition, at the ſame Diſtance from, and directly oppoſite to, the Organs of Sight.

The Water was thus weighed in two Flaſks of different Capacities; one of them contained one Pint and about an Ounce Meaſure, the other two Pints and about four Ounces Meaſure.

The Event of many Trials with Waters of the Heat of 46°, 48°, and 54°, of Fahrenheit's Thermometer, and of the ſame Heat as that of the ſurrounding Medium, was, that

Diſtilled-Water was lighter than any of the other Waters examined; a Pint of each of which exceeded the Weight of this Bulk of diſtilled Water in the following Proportions.

Rain-Water was two or three Grains,

Buxton-Water, ſeven different Parcels, was from ſix to eight Grains,

Pump-Water, which was a hard Water, was from eight to ten Grains,

Another hard *Pump-Water*, was fourteen to ſixteen Grains,

A petrifying Spring-Water, near *Chee Torr*, four Miles from Buxton, was ſix Grains, *Matlock-Water* was eight Grains,

The *Mixture of the tepid and cold Spring* ſpoken of p. 147, 148. was ſix Grains; and

The Water from the *Bath in Middleton Dale* was ſix Grains heavier than diſtilled Water.

In January 1782, a Pint Florence Flaſk filled with *Buxton-Water* weighed, as above-deſcribed, immediately after taking it from the Well in the new Grecian Temple, during a hard Froſt, ℔ j. ℥ iij. ʒ v. Gr. iij.

The ſame Bulk of the *cold Spring* from the Pump adjoining the Well, weighed, ℔ j. ℥ iij. ʒ v. Gr. xxiij.

Buxton-Water, heated to 86° of Fahrenheit's Thermometer, after being cooled to 44° of the ſame Scale, weighed twenty-five Grains leſs than when heated to 44°; and

Pump-Water, heated to the ſame Temperature as the laſt-mentioned Water, was twenty-two Grains lighter than when of the Temperature of 44°.

Alſo, a cubic Inch of *Buxton-Water*, was found to be half a Grain heavier than this Bulk of diſtilled Water;

— — of *Pump-Water*, was one Grain heavier than this Bulk of diſtilled Water.

— — of *River-Water*, was the ſame Weight as Buxton-Water.

Although the Balance employed upon this Occaſion was much more ſenſible than ordinary Beams, yet it was not ſo fine as ſome that might have been obtained purpoſely for Experiments of this delicate Nature.

I wiſh, therefore, the Reader to conſider the preceding State of ſpecific Gravity of theſe Waters, as repreſenting in a general Way the Difference of Weight between each; for the exact proportional Differences of Gravity of many of theſe Subſtances are very different from thoſe found by other Experimenters. So that, where important Concluſions are to be founded upon the Fact of the preciſe ſpecific Gravity of theſe Waters, it will be neceſſary to aſcertain it in a more exact Manner with finer Inſtruments than thoſe here employed.

From the above Account it appears, that by the ſimple Exerciſe of the external Senſes, we are not able to perceive any Subſtance ſuſpended or diſſolved in this tepid Water, excepting a Subſtance that is apparently a permanent Vapour in the Form of Bubbles; for this Water has no Colour, Taſte, or Smell, no uncommonly ſoft or hard Feel, and is not ſonorous. The not being ſonorous, indicates this Water not to be highly impregnated with Gas, or any other Species of permanent Vapour.

Buxton-Water, then, as it appears immediately to the external Senſes, is a ſimple or elementary Subſtance, with which is mixed a permanent Vapour.

The Appearance of this permanent Vapour, is different from that of ordinary Springs; which in general, or always, only detach ſmall Maſſes of Air, by ſtanding in a warm Expoſure. Sometimes I have ſeen Bubbles ariſing frquently from between the Seams of a Stone Pavement of a cold Bath, and alſo from the Surface of Moſs growing in Water; but in no Inſtance ſo copiouſly, and contained in a State of Suſpenſion in ſuch Quantities, as in the tepid Waters of Buxton.

This permanent Vapour is probably not Air, or it is a Compound of which Air is only a Part; becauſe the Bubbles of Air of common Spring-Water, are *brighter* and *larger* than thoſe of this tepid Water.

The Bubbles that are contained ſo copiouſly in Buxton-Water, are not thoſe of that acidulous permanent Vapour called Gas; becauſe Spring-Waters that detach Gas ſpontaneouſly, from the Laws of Chymiſtry, muſt be, and actually are, ſaturated with this Vapour, and conſequently *taſte acidulous*; but theſe tepid Waters, although they ſeparate a permanent Vapour, probably different from Air, are *inſipid.*

Moreover, I venture to propoſe, that Gas may be diſtinguiſhed, when ſuſpended in little Maſſes or Particles in tranſparent and colourleſs Fluids, from this permanent Vapour of Buxton-Water and Air, ſuſpended in ſuch Fluids. The Particles of Gas ſeen in Fluids, are much ſmaller than thoſe of

Air; they are almoſt opaque, and gray or whitiſh, not much unlike exceedingly minute Particles of white Sand in Fluids, as in Water already ſaturated with Gas, and in fermenting Liquors; whereas, the Bubbles of Air in Fluids, as in Water, are larger and much brighter than thoſe of Gas; they are tranſparent and ſparkle like Stars, and are apparently more viſcid than Gas; as appears by their being ſo apt to adhere to the Sides of Veſſels. The diſtinguiſhing Properties here related, may be moſt clearly obſerved by filling a Decanter with freſh Spring-Water, and ſetting it in a warm Room; on ſtanding, Air-Bubbles will manifeſt themſelves by adhering to the Sides of the Glaſs, where they ſparkle and are bright as Stars. Compare theſe Appearances of Air in Water with thoſe of Gas in Water, by pouring Pyrmont-Water from one Veſſel into another Glaſs-Veſſel, or by decanting a Bottle of briſk domeſtic Wine or Champagne: The Pyrmont-Water and Wines will appear replete with exceedingly ſmall whitiſh Particles, without the Tranſparency or Splendour of the Air-Bubbles in the Veſſel of Water.

This permanent Vapour of Buxton-Water, is not hepatic Air, or any other phlogiſtic Vapour, becauſe it is inodorous.

Oil of Metals is contained in ſome Springs, and the Appearnces of the permanent Vapour of Buxton-Water do not, that I know of, diſcover it to be a different Subſtance; or that this Subſtance is not a Part of the permanent Vapour of this Water.

A permanent Vapour has been lately diſcovered in ſome Waters, as thoſe of Bath, that ſeparates itſelf ſpontaneouſly, perhaps, with nearly the ſame Appearances as that of Buxton-Water, of which we ſhall take Notice hereafter, called *phlogiſticated Air*, but without Proof of its being *the Compound of Air and Phlogiſton*; and we have endeavoured (Page 112 to 116) to render it probable, that the Vapour, called *Choke-Damp*, *Mephitis*, or *Mofette*, is *the Compound of Air and Phlogiſton*, and very generally contained in the Cavities of the Earth, all over the Globe.

Therefore, the permanent Vapour of this tepid Spring, may, for any Thing we know to the contrary, be partly, or entirely, *the ſubterraneous Compound of Air and Phlogiſton.* But as human Induſtry has been employed only lately to diſcover the Properties of Subſtances in the State of permanent Vapour; and, as we at preſent diſtinguiſh only a few Species of Things in the Form of permanent Vapour, it is probable, there exiſt in Nature, as great a Number of Kinds of Subſtances in the State of *Vapour*, as in that of *Fluidity* or *Solidity.* On the Diſcovery of any permanent Vapour with new Appearances, we ſhould therefore recollect, how very little we know of the Hiſtory of Subſtances in this Form, and the Probability of its Difference from Subſtances already known.

The external Senſes, ſimply applied, and the Thermometer with greater Preciſion, inform us, that theſe tepid Springs much exceed the Heat of ordinary Fountains.

Common Springs taſte cold, and feel cold, when the Body, or Part of it, is immerſed in them; and ſteam when the Atmoſphere is extremely cold, or leſs cold but moiſt. They expand the Quickſilver in Fahrenheit's Thermometer, in general, from 48° to 54°, in the South Part of England; about Edinburgh, from 46° to 48°; and in the middle Part of England, the Temperature of cold Springs is, perhaps, from 48° to 50°.

I found the Heat of above thirty Springs in the Neighbourhood of Doncaſter, in the Winter Seaſon, flowing from Lime-Stone and Sand-Beds, to be included between 48° and 50° of Fahrenheit's Thermometer; and two or three others of only 47° of this Thermometer.

The Heat of cold Springs about Buxton, is between 47° and 49°; and thoſe at Matlock 49° to 50°.

It will require many more Obſervations, fully to determine the Heat of Springs in the different Regions of this Iſland, and is a moſt uſeful Part of natural Hiſtory (*q*).

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(*q*) The mean Heat of the Springs near Edinburgh ſeems to be about 47°, and at London 51°; and it is probable, the mean

The tepid Water of Buxton *taſtes rather warm, feels tepid,* or *agreeably cool,* and expands the Mercury in Fahrenheit's Thermometer about 30° more than ordinary cold Springs, i. e. to 81° or 82°.

It feels warmer, like all cold Springs, but is not actually warmer, in Winter than Summer. *Pliny*, and ſome other antient Writers, ſay, Springs are colder in Summer than in Winter; they ſhould have ſaid, *feel* colder in Summer than in Winter.

A Spring of ſuch a tepid Temperature as the Water of Buxton, is a ſingular Degree of Heat: For thoſe Springs called warm Waters, *Thermæ*, greatly exceed the Heat of theſe tepid Waters, and are not uncommon; but excepting the Matlock-Water, which is 68° or 69° of Heat, I know of none of the ſame Degree, or of intermediate Degrees of Heat, between the Heat of cold Springs and that of warm Waters.

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mean Heat of good Springs in any Country, is very nearly the mean Heat of the Country.—Ph. Tranſ. Vol. LXV. P. II. p. 60.

Dr. Heberden obſerves, "we ſhould have an eaſy Method of finding the mean Heat of any Place, if it be always nearly equal to that of its Springs. This Matter may be aſcertained by a proper Number of Obſervations, and it is therefore very deſirable to have an Account taken of the Heat of the Springs wherever a Regiſter is kept of the Heat of the Air."

Cold Springs ſteam only in very cold, or cold and moiſt Weather; becauſe at other Times, the Air diſſolves the Water as faſt as it is evaporated.

The tepid Springs of Buxton, on Account of their ſuperior Heat, evaporate more Water than the cold Springs; and ſo much, that unleſs the Atmoſphere be warm, or dry and of a temperate Heat, the whole of it cannot be diſſolved; therefore it is ſuſpended in the Form of *Steam*.

The Reader will comprehend this Explanation, by referring to the Principles of Solution, ſtated Page 123, 124.

Buxton-Water ſteams in the Bath-Room, although the Air be from 72° to 76°, which far exceeds the greateſt general Heat of Summer; becauſe the Air of the Bath-Room is kept conſtantly almoſt compleatly ſaturated with Water, and therefore can diſſolve but a ſmall Part of that which continues to be evaporated.

The Heat communicated by the Bath of Buxton to the Air being uniform, might be employed for many uſeful Purpoſes, in various Arts, in domeſtic Œconomy, Vegetation, and Phyſick; by making a Communication between the Bath-Room and other cloſe Rooms, and excluding more perfectly the external Air.

The Occaſion of this Heat, being ſo much ſuperior to that of other Springs in general, will be conſidered hereafter.

The ſpecific Gravity of Water is, *cæt. par.* in Proportion to the Quantity and ſpecific Weight of the Subſtances diſſolved therein; hence, by this Property, we judge of the Purity of Springs.

Celſus, when he aſſerts, that Ice and Snow-Water are heavier, according to the Balance, than Rain, Fountain, Well, or River-Water, is in an Error: His Words are, "Aqua leviſſima pluviatilis eſt; deinde fontana; tum ex Flumine, tum ex Puteo; poſt hæc ex nive aut Glacie."

It appears, that Buxton-Water does not differ conſiderably in ſpecific Gravity from various cold Springs, when they are of the ſame Temperature; in general it is lighter, and always as light as theſe Waters.

But an equal Bulk of Buxton-Water, immediately after being taken from the Spring, weighs much leſs, 20 Grains in a Pint leſs, than cold Spring-Water. For this there are two Reaſons; firſt, the ſuperior Heat of the Water; and ſecondly, the *permanent Vapour* ſuſpended in it.

To the Vulgar it is wonderful, that Springs of different Qualities ſhould be near each other; that a cold and warm Water; a hard and ſoft Water; a pure and a chalybeate Spring, ſhould be found within the Compaſs of a few Yards, as happens at Buxton: But to a Perſon tolerably acquainted with the Structure of the Earth, theſe Differences may be readily accounted for; without which Knowledge, however, they muſt be acknowledged to be rather extraordinary Appearances.

This is the Inſtruction we have received concerning the Properties of Buxton-Water by the immediate Perception of the external Senſes, and by the Aid of Inſtruments for the Purpoſe of diſcovering its ſimple Qualities; but as the Properties of Things are frequently not manifeſt to the Senſes, either on Account of the Minuteneſs of the Quantity of them preſented to the external Senſes, or from their Nature, we call in to their Aid Inſtruments and Experiments.

SECTION II.

Containing Experiments to ſhew, by Means of Mixture of Subſtances with the tepid Water of Buxton, whether any or what Things are contained therein.

I. SALTS.

A. *Acids.*

Exper. I. INTO a two Ounce new Flint Phial with a Glaſs-Stopper, previouſly rinſed repeatedly with diſtilled Snow-Water, was introduced a Shred of dry Paper dyed by immerſing it in Infuſion of *Archill.* This Phial was filled with the tepid Spring-Water at the Well, and while under the Water cloſed with the Stopper; and out of it preſerved inverted.

A clear and new Flint Phial, containing about two Ounce Meaſures, firſt well cleaned with diſtilled Snow-Water, was filled with this diſtilled Water, into which was introduced a Shred of Paper dyed with Infuſion of Archill of the ſame Parcel as that laſt uſed, and cloſed with a ſound Cork; and

A third Phial of the ſame Kind, and rinſed in the ſame Manner as the former, was filled with diſtilled Snow-Water nearly ſaturated with Gas ſeparated from Marble by vitriolic Acid, and a Piece of Paper ſtained with Archill, of the ſame Parcel as the former, was introduced therein. After theſe three Phials of Water and dyed Paper had ſtood two or three Hours, and alſo twenty-four Hours in the ſame Temperature, the Water of the *firſt mentioned* Phial was of a *dilute purple Colour*, and the Paper of a *deep Purple.* On adding to this Water a few Drops of a Mixture of a thouſand Parts of Water and one Part of vitriolic Acid, the Water and Paper immediately turned *pale red.*

In the ſecond named Phial the Water was ſcarcely tinged of a *pale purple Colour*, and the Paper was of a *paler Purple* conſiderably than in the firſt-mentioned Bottle, and even had rather a *reddiſh Caſt.*

In the third Phial the Paper was *reddiſh*, and the Water juſt tinged of a *reddiſh Hue.*

The Buxton-Water did not change the purple Colour of the Archill red, applied under Circumſtances that muſt have expoſed this Subſtance to the Action of the moſt volatile Acid had it been contained in the Water; but the dyed Paper became of a deeper Purple than that in diſtilled Water, and as ſome of the ſame Parcel of ſtained Paper was turned *rediſh* by the Application of the weakeſt Acid, Gas, and by an extremely diluted and almoſt inſipid Solution of vitriolic Acid in Water, we cannot from this delicate Teſt of Acidity diſcover any Appearance that indicates an Acid contained in this tepid Water.

Exper. II. Two Ounces of *Lime-Water* were added to a Jar containing about ſix Ounces of Buxton-Water immediately after being taken from the Spring. A Pearl-coloured Mixture was inſtantly produced, from which by ſtanding a woolly Sediment in a colourleſs tranſparent Fluid was depoſited.

To another Jar of the ſame Kind as the laſt, with the ſame Quantity of the Pump-Water near the Well as the former Jar contained of Buxton-Water, were added two Ounces of Lime-Water; a Mixture of the ſame Kind, and Sediment in the ſame Quantity as the former appeared on the Addition of the Lime-Water.

This Experiment was intended to ſhew, whether that particular acidulous permanent Vapour called Gas was combined with Buxton-Water, which is well known, when diſſolved in Water by Nature or Art, to combine with Quicklime diſſolved in Water; thereby producing a calcareous Earth or earthy Salt ſoluble in a very ſmall Proportion in Water, that occaſions the Water to become turbid, and on ſtanding to depoſit a white Sediment. Theſe Appearances denoting Gas were obſerved in this Experiment in Buxton-Water, and common Pump-Water; and they are viſible in by far the greateſt Number of Spring-Waters, perhaps, in the whole Kingdom. We ſhould therefore be apt to conclude, that Buxton-Water, as well as many other Springs, contains Gas; eſpecially as the Precipitation here made, may be proved by Obſervations and Experiments to be Quicklime and Gas. I apprehend, however, that ſuch a Concluſion drawn from this Experiment is falſe, and we ſhall hereafter relate the Proofs, *that there is no Gas in Buxton-Water combined with the Water*; and that the Appearances above related hitherto ſuppoſed to demonſtrate its Exiſtence in Water, probably depend upon a different Cauſe, viz. *Gas united with the Compound of Gas, and Quicklime combining with the Quicklime diſſolved in the Lime-Water added; as I ſhall ſhow, that calcareous Earth, perhaps, is not Quicklime united with Gas, but a Compound of Quicklime and Gas combined with Gas.*

An additional Proof of the Truth of this Concluſion may be found in Experiment I. which ſhews, that this tepid Water does not contain a ſufficient Quantity of Gas, if any Portion of this Subſtance, to diminiſh or change the purple Colour of Archill; on the contrary, it renders this Subſtance of a deeper Purple, which is an Effect of Alkali. To theſe Obſervations add thoſe of Pages 155 and 165, and this Concluſion will be more fully eſtabliſhed.

Exper. III. A ſmall Quantity of *Iron-Filings* was, ſeveral Times, added to a Phial of Buxton-Water, at the Well, and there corked cloſely and agitated. To this Water poured off and filtered, about half an Hour after being thus mixed with Iron-Filings, was added *Powder of Galls*. In one Caſe, the Water was by this Addition turned of a purple Colour; but in three other Caſes no Colour was produced, either immediately, or after ſtanding ſeveral Hours.

To Buxton-Water deprived of its *permanent Vapour which ſeparates ſpontaneouſly*, and of its *reſpirable Air*, in which had been mixed Iron-Filings, and the Mixture afterwards filtered as above-related, was added Powder of Galls. In one Inſtance it became, by the Addition of Galls, immediately brown, but in three other Caſes, not until after ſeveral Hours.

Buxton-Water was deprived, by Lime-Water, of the *Gas* it contains, perhaps united with *the Compound of Gas and Quick-Lime*; and Buxton-Water was alſo deprived of the whole of the three Kinds of permanent Vapour it contains, viz. *The permanent Vapour that ſeparates in great Quantities ſpontaneouſly, reſpirable Air,* (both which are combined with, and ſuſpended in, this tepid Spring,) and the *Gas* combined with *the Compound of Gas and Quicklime.* Iron-Filings were mixed and agitated with Water thus deprived of its *permanent Vapours*; and to theſe Mixtures filtered, after *ſtanding a few Hours,* were added Powder of Galls; by which no Colour was produced in leſs than two Hours, and then only a brown Colour, apparently from the Galls merely infuſed in the Water, independent of Iron. With ſome of theſe Mixtures, filtered, after *ſtanding ſeveral Days,* the Galls produced a *reddiſh, purple, pink,* or *dark blue,* and *black Colour,* either immediately or on ſtanding.

The various Shades of blue, red, and black, produced by Galls mixed with filtered freſh Spring-Water, and with Water artificially impregnated with Gas, in which Iron-Filings had been agitated, has been the Reſult from which it was concluded, and generally believed, that a Spring contained Gas combined with, or ſuſpended in, the Water: Alſo, that in common chalybeate Springs, Gas was the Solvent of the Iron. But, as it is ſhown in this Experiment, that not only Buxton-Water apparently containing Gas, but certainly deprived of this, or any, or all of its permanent Vapours, ſometimes produces, and at other Times does not produce Colours with Galls, under equal Circumſtances, it may be inferred, *that Gas is not the Solvent, or not the only Solvent of Iron in Water, but, perhaps, that Water alone will diſſolve Iron.* And it will be ſhewn hereafter, by the moſt deciſive Experiments, that Gas is not the only, or not by much the moſt uſual Solvent of this, or other Metals in Mineral-Waters.

I recollect that Dr. Fordyce, in his chymical Lectures mentioned, that the Water of a Smith's Shop, in which red hot Iron is cooled, contains Iron diſſolved therein; which Solution, however, I apprehend, frequently does not take place, becauſe only the Aſhes (*r*) upon the Surface of the red

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(*r*) The Scales beat off from red hot Iron, are as much mere Aſhes, as the Aſhes of Pit-Coal, or other Inflammables. Like Aſhes of other Subſtances, they are the Product of Inflammation; for Iron is deciſively an inflammable Subſtance, or will burn, as well as Oil, Alcohol, or dried Vegetables: But the burning or Inflammation of Iron, is not obvious in the ordinary Way, namely, the ruſting of it in the Air, and the Calcination of it by Heat: However, under particular Circumſtances, it burns as diſtinctly as a Tallow Candle. When I was a Student of Chymiſtry at Edinburgh, about nine Years ago, I made a Bar of Iron, that had been expoſed to the Heat of a large Kitchen Fire for many Years, evidently burn; by firſt heating it red hot, or perhaps, white hot, and in this State, expoſing it to the Blaſt of Air from the large Bellows of an Iron Furnace; it then became fluid, emitted Flame, and as the Flame extended, little fluid Maſſes dropped off from the End of it, which, when collected, were exactly like a common Pit-Coal Cinder. Neither this apparent red hot Metal are, in general, expoſed to the Action of the Water; and, upon mixing Galls with this Water, I found that it ſometimes produced a purpliſh Colour, but in general no Colour, excepting that of Infuſion of Galls in Water.

Common River, and Pump-Water, which had Iron-Filings infuſed in them and filtered, ſometimes produced Colours with Galls, but at other Times did not produce any Colours, or only a *grey-coloured turbid Fluid.* Mr. *Boyle* found, that Water in which Iron-Filings had been infuſed, produced an inky Colour with Galls; but ſome-

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rent Cinder, nor the Scales above-mentioned, are reducible to a metallic State; nor, if I recollect rightly, are the Aſhes called Flowers of *Zinc*, left, after burning Zinc, capable of being reſtored to the State of a Semi-Metal.

All the Metals and Semi-Metals, are, perhaps, *inflammable*, although we may not know the Circumſtances neceſſary to make them burn.

Cramer, in the laſt and German Edition of his *Anfangs-Gründe der Metallurgie*, Fol. 1776, ſhews *Antimony* to be capable of burning.

I do not know, whether the inflammable Property of Antimony be much known; that of Iron is, I imagine, a Thing with which many Readers are acquainted.

Arſenic alſo burns diſtinctly, provided it be expoſed to a proper Degree of Heat.—See *Bergman's* Sciagraphia Regni Min.

We have a familiar Example of the burning of Iron, ſo as to produce *Heat*, *Light*, and *chymical Analyſis*, in the Inſtance of ſtriking Fire with a Flint and Steel; the Particles produced by the Stroke, are nothing more than Particles of Steel ſeparated by the hard Flint, and ſet on Fire by the Violence of the Stroke.

times no Colour. He alſo relates, that Infuſion of Galls poured upon Steel-Filings of which Needles were made, produced an opaque Liquor, and of a dark inky Colour; which Colour it retained upon Filtration. I do not, however, mean to infer, that Gas alone, and alſo Water ſaturated with this Subſtance, may not diſſolve or ſuſpend Iron in greater Quantity than ſimple Water; but that the Inference is fallacious, that Buxton-Water contains Gas, becauſe, after Iron-Filings have been expoſed therein, a Colour is produced, on the Addition of Galls, peculiar to Solutions of this Metal.

Iron-Rods, or Rails, and Iron Chains, are continually ſuſpended over the Surface of the Bath at Buxton, yet it does not appear that this Metal here ruſts faſter than in common Water or moiſt Air. Were this tepid Water ſaturated with Gas ſo as to detach it ſpontaneouſly, from the Property of Water ſo impregnated of diſſolving or ſuſpending Iron, a more ſpeedy Solution might be expected.

B. *Alkalies.*

Exper. IV. A Phial with a Glaſs-Stopper, of the ſame Kind as that employed Exper. I, containing half an Ounce of *Syrup of Violets*, was filled with the Buxton tepid Water, by immerſing it in the Well, and being there cloſed with the Stopper, was withdrawn, agitated, and preſerved inverted. This Mixture was at the ſame Time compared with Syrup of Violets, of the ſame Parcel as the former, and diſtilled Water; and with a third Mixture of the ſame Syrup and common Pump-Water; both of which Mixtures, contained the ſame Proportion of Syrup and Water as the firſt Mixture.

The Mixture containing Buxton, and that with Pump-Water, appeared of *a bluiſh-green Caſt*, pretty much alike; which Colour became, commonly, a pale green on ſtanding; but the other Mixture was of a *pale blue Colour.*

In other Inſtances, with a different Parcel of Syrup of Violets, the Mixture with the tepid Water, recently taken from the Well, and that with the Pump-Water, were of *a bluiſh Colour:* And with Buxton-Water that had been preſerved corked ſome Time in Bottles it was generally *bluiſh.* From various Trials it appeared, that Buxton-Water, recently taken from the Spring, and Syrup of Violets, generally formed a *green* Mixture; and Buxton-Water, which had been ſome Time kept in Bottles, and Syrup of Violets, generally made *a bluiſh Mixture.*

A few Drops of an almoſt inſipid Solution of fixed Alkali in diſtilled Water, turned all the above Mixtures of a *pale green Colour* immediately.

Exper. V. A Drachm of *Nitre of Magneſia* (without the ſmalleſt Portion of ſuperfluous Acid) was added to four Ounces of Buxton tepid Water at the Well. This Mixture remained clear after ſtanding twenty-four Hours. The ſame Quantity of Nitre of Magneſia was added to eight Ounces of Buxton-Water, and the Mixture was clear after ſtanding ſome Time. Two Drachms of Nitre of Magneſia were added to a Jar containing a Pint of this tepid Spring, and not the leaſt Precipitation occurred during two Days.

The greeniſh Colour commonly produced by Buxton-Water and the blue Juices of Vegetables, is reckoned a certain Proof of the Preſence of an Alkali; but, many other Subſtances beſides Alkali produce this Colour, and ſeveral of theſe are commonly contained in Spring-Water, viz. calcareous Earth, and earthy Salts in general, as vitriolic Selenites. Alſo, Nitre of Magneſia, nitrous Acid ſo ſaturated with Lead as to form Cryſtals, changed the Syrup employed in Experiment IV. green, &c. This Appearance, therefore, alone is but an equivocal Sign; however, in Conjunction with other Obſervations and Experiments, it is pretty deciſive.

Exper. V. ſhews clearly and deciſively, that the green Colour produced in the IVth Experiment, was not occaſioned by Alkali in this tepid Water; becauſe Nitre of Magneſia is decompoſed by the ſmalleſt Portion of Alkali in Water, and no other Subſtance in Water is known to decompoſe this earthy Salt.

C. *Vitriolic Acid combined with Alkalies, Earths, and Metals.*

Exper. VI. To a Wine-Glaſs full of this tepid Water, immediately after being taken from the Well, were added ten Drops of nitrous Acid, upon which Mixture, were poured thirty Drops of *Solution of Lead* in nitrous Acid. The Addition of this Solution, occaſioned a turbid Appearance immediately. On ſtanding, there was a copious Depoſition of cloſe grey Sediment, adhering cloſely to the Sides of the Glaſs.

The ſame Appearances happened with a like Mixture, and a hard Pump-Water, inſtead of Buxton-Water.

Alſo the ſame Mixture was made, preciſely as the laſt, with diſtilled Water inſtead of this tepid Spring, and the Mixture was neither turbid, nor had it any Sediment on ſtanding.

From the preceding Experiment it may be concluded, that *vitriolic Acid* in the Water, combined with the Lead diſſolved in nitrous Acid; and, as the Compound of Lead and vitriolic Acid is a Salt very ſparingly, or not at all, ſoluble in Water, it is upon this Occaſion precipitated. As a Decompoſition may be produced on adding Solution of Lead in nitrous Acid to Water containing Alkali, abſorbent Earths, or Metals, or in Conſequence of *mere Dilution*; nitrous Acid was previouſly added, ſufficient to ſaturate any ſuch Subſtances in Buxton-Water, and to prevent Decompoſition by Dilution: And it is proved by this Experiment of the Mixture of diſtilled Water inſtead of Buxton-Water, that *mere Dilution* did not decompoſe this Solution of Lead; therefore it may be fairly inferred, that *the Precipitation ariſes from vitriolic Acid*; but whether this Acid be combined with Water, or other Subſtances, cannot be determined by this Experiment.

D. *Muriatic Acid combined with Alkali, Earths, or any other Subſtances.*

Exper. VII. To a Wine-Glaſs filled with this *tepid Water* were added at the Well, firſt, five Drops of nitrous Acid, and then ten Drops of *Solution of Silver* in nitrous Acid. Upon this Solution being poured into this Glaſs of Water, there was a Pearl-coloured turbid Appearance, and in ten Minutes a copious whitiſh Sediment took Place, which, on ſtanding, changed to a purpliſh Colour.

Nearly the ſame Appearances happened with Pump-Water, uſed in this Experiment, inſtead of Buxton-Water.

This Mixture, made with diſtilled Water, was tranſparent, and without Sediment; but upon adding *Sea-Salt*, in Quantity a thouſandth Part of the diſtilled Water, a Precipitation like that of the other Mixtures enſued.

As the nitrous Acid added in the above Experiment, was ſufficient to ſaturate any Alkali or Earth contained in the *tepid Water* examined, and prevent the Solution of Silver from being decompoſed by Dilution with Water, I deduce, that the Pearl-coloured Appearance and Precipitation was occaſioned by *muriatic Acid* combining with the Silver diſſolved in nitrous Acid; and that the nitrous Acid would at the ſame Time diſſolve the Alkali, Earth, or probably other Subſtances combined in the Water naturally with the muriatic Acid, provided this Acid be not combined with the mere Water.

As muriatic Acid is ſo very generally, perhaps, univerſally, contained in Spring-Water, it is not remarkable that it ſhould be found in the Pump-Water, ſubjected to the Teſt of this Experiment.

E. *Calcareous Earth; which is perhaps Gas combined with the Compound of Gas and Quicklime.*

In another Part of this Work it will be ſubmitted to the Opinion of the Reader, whether calcareous Earth ſhould not be conſidered as an earthy Salt compoſed of an Acid, which is a permanent Vapour; namely, *Gas*, and a Subſtance which appears to be a Species of Alkali, viz. *Quicklime*. Alſo, whether I have not diſcovered, that calcareous Earth is compoſed of Gas united to a Compound of Gas and Quicklime.

Dr. *Cullen*, I am well-informed, in his chymical Lectures, uſed to reckon Quicklime an alkaline Subſtance.

Exper. VIII. To a Pint Jar of *Buxton-Water* was added a Drachm of *ſaturated Solution of Lead* in nitrous Acid.

This Mixture was at firſt *ſlightly muddy*, and, on ſtanding, depoſited a *brown* or *gray Sediment.* After decanting the clear Water, the Sediment was dried, and a Drachm of nitrous Acid was poured upon it: After ſeveral Days Expoſure in a gentle Heat in a warm Room, *a Part of this Sediment appeared to be diſſolved.*

To another Jar, containing a Pint of *Buxton-Water*, was added about one Drachm Meaſure of nitrous Acid, and the ſame Quantity of Solution of Lead in nitrous Acid: This Mixture was *leſs turbid*, and depoſited a *ſmaller* Quantity of Sediment than the former Mixture. After pouring off the clear Fluid, the Sediment was evaporated to Dryneſs, and mixed with about a Drachm Meaſure of nitrous Acid: This Mixture was expoſed in a warm Room, the ſame Space of Time as the former Mixture of Sediment and nitrous Acid, when either a much ſmaller, or no Solution appeared to have taken Place.

A Drachm Meaſure, or thereabouts, of the *ſaturated Solution of Lead* in nitrous Acid, was added to a Pint Meaſure of *diſtilled Snow-Water*: On ſtanding ſeveral Days, expoſed to the Atmoſphere, the Tranſparency of this Mixture appeared much diſturbed, but no Sediment could be diſtinctly perceived.

From the *two firſt of theſe Mixtures* it may be inferred, that *there is calcareous Earth diſſolved in this tepid Water*; for in the firſt of them, the Solution of Lead is decompoſed, by the Quicklime of this Earth combining with ſome of the Acid in which this Metal is diſſolved; and the Gas, the other Element of which calcareous Earth is compoſed, probably, at the ſame Time, joins the Calx of Lead rather than the Water: The Compound, thus formed, of nitrous Acid and Quicklime, is diſſolved by the Water; but the Compound of Calx of Lead and Gas, is not ſoluble in Water; therefore, it is depoſited in the Form of Sediment. As the Solution of Lead, added in this Experiment, contained more nitrous Acid than is ſufficient to ſaturate the Quicklime in this Quantity of Water, the ſuperabundant Solution of Lead is alſo decompoſed, by vitriolic Acid in the Water combining with the Calx of Lead; thereby forming a metallic Salt, which, being ſoluble in an exceedingly ſmall Quantity of Water, the greateſt Part of it is depoſited in the Form of a Sediment; while the nitrous Acid unites with abſorbent Earth (if the vitriolic Acid be combined with Quicklime or Magneſia) forming a Salt of ready Solubility in Water: So that the Sediment found, in the firſt of theſe three Mixtures,

tures, was probably Calx of Lead, combined with Gas, and another Compound, viz. Calx of Lead and vitriolic Acid; therefore, on expoſing this Sediment, for ſeveral Days, to the Action of nitrous Acid, the Whole or a Part of the Calx of Lead would be liable to be diſſolved in this Acid; which accounts for the Diminution in the Quanty of Sediment, after the Mixture of this Sediment with nitrous Acid.

In the *ſecond of theſe two Mixtures*, the nitrous Acid, added to this tepid Water, would neceſſarily ſaturate any abſorbent Earth diſſolved therein; therefore, the turbid Appearance, and ſubſequent Formation of Sediment, muſt be ſolely aſcribed to the Combination of vitriolic Acid and Calx of Lead, in the ſame Quantity as in the firſt Mixture; but as the firſt Mixture, not only contained the Compound of Calx of Lead and vitriolic Acid, in as great a Quantity as the ſecond Mixture, but the Calx of Lead in Conjunction with Gas, the Sediment muſt be *greater* in Quantity; and no Diminution of the Quantity of the Sediment of the ſecond Mixture happened when digeſted with nitrous Acid, becauſe the whole of it was a Compound of vitriolic Acid and Calx of Lead.

The Diminution of Tranſparency, and even the ſomewhat *turbid Appearance* of the *third Mixture*, on Expoſure to the Atmoſphere, was occaſioned by the *mere Dilution of the Solution of Lead*

Lead in Water. For all dilute Solutions of metallic Salts decompoſe ſpontaneouſly, certainly if expoſed to, and perhaps alſo when excluded from the Atmoſphere. This, by the Way, accounts for the Decompoſition of chalybeate Waters erroneouſly referred to the Eſcape of Gas, of which we ſhall ſpeak more fully hereafter. There was no Sediment formed, becauſe the Particles of the Calx of Lead were too minute, and ſuſpended in too large a Bulk of Water, to be able to overcome the Coheſion of this Fluid.

Exper. IX. Into a Jar, containing half a Pint of *Buxton tepid Water*, were poured three Teaſpoonfuls of ſaturated and filtered *Solution of corroſive Sublimate* in diſtilled Water; and to eight Ounces of *diſtilled Water*, was added about a Drachm Meaſure of this *Solution of Sublimate* in Water.

For ſome Hours the above Mixtures remained *tranſparent*; but after ſtanding a Day or two, the former of them depoſited a *cloſe gray Sediment*, and the latter had its *Tranſparency diſturbed.*

As it is ſhewn by Experiments IV. and V. that this Spring-Water contains no Alkali, the Precipitation in the Jar of Buxton-Water is occaſioned, principally, by *calcareous Earth* in the Water; for the Quicklime of this Subſtance combines upon this Occaſion with the muriatic Acid of the corroſive Sublimate, while the Gas of the Earth unites either with the Calx of the Quickſilver,

ſilver, or the Water; and thus a turbid Appearance and Sediment is produced. In Part, however, the Decompoſition ariſes from the Solution of the metallic Salt here employed being extremely diluted.

The Diminution of Tranſparency in the ſecond Jar of the Mixture on ſtanding, was occaſioned merely by the Decompoſition of the metallic Salt with ſo large a Quantity of Water.

Exper. X. Four Grains of *Saccharum Saturni* were diſſolved in a half Pint Glaſs of *Buxton-Water*, which immediately made a *turbid Appearance*; and, after ſtanding, there was a Depoſition of a *copious Sediment.*

A like Mixture with diſtilled Snow-Water, (which diſtilled Water was previouſly found to contain no Gas, either combined with the Water or with Quicklime) was immediately rather milky, but not ſo turbid as the former Mixture; and after remaining at Reſt, let fall *a leſs copious Sediment* than the other Mixture.

We only know two Things that could, upon this Occaſion, produce the turbid Appearance and Sediment in the *Buxton-Water*, viz. *calcareous Earth*, acting upon this metallic Salt in the Manner related in the Obſervations upon the laſt Experiment; and *Dilution.*

The Appearances in the *other Mixture*, are occaſioned entirely by a *Decompoſition* of this metallic Salt in Conſequence of *Dilution.* The turbid Appearance and Sediment is remarkably great with this Salt of Lead, and a large Quantity of Water; and the Decompoſition being ſo much more ſpeedy of *Saccharum Saturni* by Water, than of other metallic Salts, or earthy Salts, it may be conſidered as the moſt ſtriking Inſtance of the Property in general of Decompoſition of metallic, and earthy, and perhaps neutral Salts, by dilute Solution in Water.

I take this Opportunity of pointing out a Miſtake in the generally received Opinion, that Water ſaturated with Gas decompounds Sugar of Lead in Conſequence of the Gas combining, from its ſtronger Attraction than acetous Acid, with the Calx of Lead. Thoſe who have made this Experiment, and drawn this Concluſion, did not at the ſame Time perform the Experiment with ſimple Water, or recollect the Fact, that *metallic Salts are decompoſed by Dilution with Water* (r).

(r) This Opinion is founded entirely on the following Experiment, related in the Appendix, p. 291, of the firſt Volume of Dr. *Prieſtley's Experiments and Obſervations on different Kinds of Air*. "Diſtilled-Water ſaturated with fixed Air, formed a white Cloud and Precipitation upon being mixed with a Solution of Saccharum Saturni." I remark upon this Part of the Experiment, that the ſame Appearance takes Place with ſimple Water. "I found likewiſe that fixed Air, after paſſing through the Tube filled with alkaline Salt, upon being let into a Phial containing a Solution of the metallic Salt in diſtilled Water, cauſed a perfect Separation of the Lead

F. *Subſtances compoſed of any Earth or any Metal with any Acid, forming neutral Salts with any earthy or metallic Baſes, excepting the earthy Salt, calcareous Earth, conſiſting of Gas and Quicklime, or, perhaps more juſtly, of Gas and the Compound of Gas and Quicklime.*

Exper. XI. Two Drachms Meaſure of a perfectly clear Solution of *pure fixed vegetable Alkali*, in a mild State, were added to a Jar containing four Ounces of *Buxton-Water*: This Addition rendered the Water immediately *turbid*, and on ſtanding, there was a *copious Depoſition of white Sediment.*

Lead in the Form of a white Powder; for the Water, after this Precipitation, ſhewed no Cloudineſs upon a freſh Mixture of the Subſtances which had before rendered it opaque." Upon the latter Part of this Experiment I remark, that unleſs a Phial containing Solution of Sugar of Lead without Gas, had been compared along with the Phial of Solution into which Gas was transferred, it is uncertain whether the Decompoſition was occaſioned by the Water alone, or by the Gas in the Water; perhaps, however, the Precipitation is rendered more compleat and ſpeedy by the Gas contained in Water.

The Author of a *Treatiſe on Gaſes*, ſays, " This Gas occaſions a *Precipitation* in a Solution of *Sugar of Lead,* as Mr. *Hey* of *Leeds* obſerves."

Mr. *Cavallo* alſo, in his late Work on *Air* and *other permanently elaſtic Fluids*, 4to, on the Event of the Experiment here related, ſays, that fixed Air decompoſes Lead diſſolved in acetous Acid.

The ſame Appearance occurred on the Addition of the *above Solution* to common *Pump-Water*; but *Solution of mild Alkali* and *diſtilled Water* formed *a clear Mixture.*

The Matter here depoſited, was, in all Probability, a Subſtance which might have been combined with any Acid, excepting Gas; for I found that mild Alkali did not decompoſe or precipitate Solution of calcareous Earth in diſtilled Water. From the Colour of the Sediment, independently of the preceding Facts, it is moſt probable it was entirely, or principally, *abſorbent Earth* depoſited in Conſequence of the Quicklime before combined with Acid now uniting with the Gas of the Alkali, and Acid combining with the pure or cauſtic Alkali.

To determine the Kind of Subſtance or Subſtances thus precipitated, which might be in too ſmall a Quantity to be obſerved by the external Senſes in the above Quantity of precipitated Matter, the following intereſting Experiment was made.

Exper. XII. To 116 Wine Gallons of Buxton-Water, contained in a brewing Tub previouſly made perfectly clean, immediately after this Water was conveyed in wooden Veſſels from the Well, was added one Pound of *Salt of Tartar*, free from extraneous Matters. This Salt occaſioned, immediately upon its Solution, a *turbid Appearance throughout the whole Fluid.* This Veſſel of Solution Mixture, after ſtanding four Days, during which Time Care was taken to exclude any Duſt, or other foreign Matters from being introduced, was become perfectly *clear*, and a cloſe gray-coloured *Sediment* was formed at the Bottom of the Tub.

Some of this clear Fluid, on the Addition of Syrup of Violets, became Graſs green; while freſh Buxton-Water turned blue with the ſame Parcel of Syrup; and a ſmall Quantity of this tranſparent Solution, with an additional Solution of Alkali, did not become in the leaſt turbid immediately, or on ſtanding depoſit any Sediment. It was therefore rendered certain, that a ſufficient Quantity of Alkali had been added to decompound the Subſtances propoſed.

As much clear Fluid as poſſible was drawn off from this Mixture, by Means of a Spigot and Faucet inſerted near the Bottom of the Tub. By allowing the remaining Mixture to ſtand, and by decanting the clear Fluid from it repeatedly, I obtained the whole of the Sediment depoſited in this Experiment, with only a very ſmall Quantity of the Solution mixed with it.

In the Manner juſt related, Sediment was procured three Times from the above-mentioned Quantity of Buxton-Water, namely, from 348 Gallons of this Water. The whole *Sediment* from the Tub filled three Times, i. e. from 348 Gallons of Buxton-Water, weighed four Ounces and two Drachms and a Half Troy; ſo that each Gallon afforded about ſix Grains of Sediment.

Sediment was alſo procured from 12 Gallons of Buxton-Water in the Manner above-related, which, when evaporated to Dryneſs, weighed three Pennyweights, twelve Grains ; ſo each Gallon of Water afforded ſeven Grains of Sediment.

This *Sediment* was an extremely light, ſmooth, gray Powder, without Taſte or Smell ; and ſuppoſing the Gas combined with this Sediment to be one-third of the Weight of this Sediment, and the Acid with which this Sediment was combined to weigh as much as the Sediment here procured, when free of Gas, or four Grains in each Gallon, then the Quantity of metallic or earthy Salt in the Water will be eight Grains in a Gallon ; provided no earthy Matter was formed and depoſited, by the dilute Solution of Alkali employed to produce this Precipitation (*s*).

All that can be determined from the ſimple Properties of this Sediment is, that it either contains but a ſmall Quantity or no Calx of Metal, becauſe it is grey.

Exper. XIII. To a ſmall Portion, about ſix Grains, of the above Sediment, was added *mu-*

(*s*) *Boerhaave*, and other Chymiſts, ſpeak of the Converſion or the Production of Earth from fixed Alkali by Solution, Dilution, Evaporation, Heat, and Expoſure to Air ; and relate Proceſſes for this Purpoſe.

Margraaf fears, that in this Experiment the Properties of the Subſtances contained in the Water may be changed ; but gives no Proof to demonſtrate this Change to obtain upon this Occaſion.

riatic Acid gradually, till the Effervefcence excited ceaſed; and it then appeared to be entirely diſſolved; and the Solution was a yellowiſh tranſparent Fluid, that had a bitter ſaline Taſte, not much unlike muriatic Selenites.

Vitriolic Acid was added, Drop by Drop, upon this Solution; which occaſioned a Depoſition of a copious white Sediment, exactly with the ſame Appearances as happened upon pouring vitriolic Acid upon muriatic Selenites.

This Experiment ſhewed, that the principal Part at leaſt, if not all the Sediment precipitated, by adding mild fixed Alkali to Buxton-Water, was *abſorbent Earth:* And, alſo, that a principal Part, or the whole of this Earth, was calcareous Earth, but did not demonſtrate whether there was not a ſmall Quantity of other abſorbent Earths, and of Calces of Metals; therefore the following Experiment was made.

Exper. XIV. To one Ounce of the above Sediment, procured from the Buxton-Water in the above Experiment, in a Glaſs Jar capable of containing two Quarts of Fluid, was added vitriolic Acid, diluted with ſix Times its Bulk of diſtilled Rain-Water, until no further Effervefcence enſued. When it was ſuppoſed a ſufficient Quantity of Acid had been added to ſaturate the whole earthy Sediment, this Mixture was expoſed in a Sand Heat twenty-four Hours, and then diluted with ſix Ounces of diſtilled Rain-Water boiling hot, and

filtered

filtered through Paper. Water was poured a ſecond Time upon the Solution, in Quantity two Pints, and filtered as before. Theſe filtered Fluids were of a light brown Colour, had a bitteriſh Taſte, and were more bitter than a Solution of vitriolic Selenites, made by diſſolving vitriolic Selenites, compoſed of Quicklime which had been combined with Water, and precipitated by combining it with Gas, and uniting this Sediment with vitriolic Acid.

To a ſmall Quantity of the above Mixture, poured off ſoon after adding the vitriolic Acid, *before it was firſt filtered*, were added a few Grains of *Galls* powdered in a Marble Mortar; by which it was changed, firſt of a *yellowiſh Colour*, then *greeniſh* and *thick*, afterwards *blackiſh*. The ſame Appearances preſented themſelves, on adding Galls of different Sorts, to ſome of this decanted Solution.

To ſmall Quantities of the above Solution *after Filtration*, were added powdered Galls of different Parcels; which, on ſtanding, became *brown* coloured, like Infuſion of Galls in Water, and *turbid*, but *no purple*, *blue*, *blackiſh*, or other Shades of theſe Colours were produced.

To ſome of this filtered Liquor was alſo added a ſmall Portion of *phlogiſticated Alkali*, or Ley of Alkali calcined with Blood (*t*), which inſtantly produced

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(*t*) See *Opuſcules Chymiques de M. Margraaf*, Tom. I. p. 81. for the Method of making *phlogiſticated Alkali*.—This moſt duced a *blackiſh Colour*, that immediately diſappeared, and left *a white* and muddy fluid. Solution of *mild fixed Alkali*, produced with this filtered

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moſt accurate and laborious Chymiſt obſerves, that the Conſideration, that *Pruſſian Blue* owes its Colour to Iron, ſuggeſted to him, that alkaline Ley, calcined with dried Blood, would readily detect any Particles of Iron in the Earths; in principally calcareous Earth, procured from Waters by Diſtillation: But, for this Purpoſe, ſuch Sediments muſt be diſſolved in Acid of Vitriol, which would form a Compound of ſparing Solubility in Water, and combined with Iron, would be readily ſoluble. Therefore, Mr. *Margraaf* ſaturated the Sediment, which was principally calcareous Earth, left after the Evaporation of Water, with diluted vitriolic Acid. The Fluid filtered from this Mixture, was a Solution of vitriolic Selenites, and the whole, probably, of any metallic Solution that might be contained therein. If any *Iron* were contained in the Water, it was manifeſted by the *blackiſh* or *blue Precipitation*, upon the Addition of this alkaline Lixivium. As this Precipitation of *blackiſh* or *blue Matter*, was obtained from the calcareous Earth of a Variety of Spring and River-Waters, as well as from the calcareous Earth of a Variety of animal Matters, which had not been ſuſpected to contain Iron, from their Appearance, Taſte, the Addition of Galls, &c. he concluded they contained Iron, which Subſtance was ſhewn by this more delicate Teſt than Galls or other Means. Further; this precipitated *blue Matter*, was deciſively proved to be Iron, by collecting it in pretty large Quantity. By Calcination, it was firſt found to be red Saffron of Iron, and then, by combining it with Phlogiſton, it was reduced to a metallic Form.

When I was a Student at Edinburgh, Dr. *Black* uſed to recommend this phlogiſticated Alkali, as a more delicate and certain Teſt of Iron in Water than *Galls*.

Fluid a turbid Appearance; and, afterwards, a Depoſition of *a white Sediment*, ſimilar to that upon adding Solution of the ſame Alkali to the Solution of the above-mentioned artificial Selenites.

The Sediment procured from twelve Gallons of Water, in Quantity 3 dwt. 12 grs. was treated exactly as the Ounce of Sediment juſt mentioned, but diluted after Solution with twenty-four Ounces of Snow-Water; and all the ſame Appearances happened, excepting, that the Liquor filtered alſo produced a *dark blue Colour* with *Galls* on *ſtanding*, as well as *ſoon after the Solution was made.*

To ſmall Quantities of Solution of the preceding artificial vitriolic Selenites, were added Powder of *Galls* of various Parcels, and alſo *phlogiſticated* and *common Alkali*, without producing *any coloured Fluids*; the Alkalies only occaſioning a Precipitation of a gray Sediment.

The preceding Solutions filtered from the *Ounce of diſſolved Sediment*, as well as that from the *precipitated Matter of twelve Gallons of Water*, and the filtered *Solution of artificial vitriolic Selenites*, were evaporated ſlowly in Glaſs Veſſels to Dryneſs. This laſt Solution yielded about half a Grain in an Ounce of Fluid; and the two former about three-fourths of a Grain to a Grain, from each Ounce of filtered Fluids. The Sediment of the Fluids thus evaporated was cryſtallized, and had a bitter Taſte. It is remarkable, that the Solution of artificial Selenites evaporated to Dryneſs afforded Cryſtals of a bitter Taſte; but before Solution, and without being cryſtallized, it had no Taſte.

The Sediment afforded by the whole filtered Fluid from the Ounce of Sediment above diſſolved and evaporated to Dryneſs, as well as that from the twelve Gallons of Water, were re-diſſolved in Snow-Water, and perfectly decompoſed by pure fixed alkaline Lixivium. They afforded a *white Sediment* without Taſte or Smell.

Twenty Grains of the preceding *Compound of Sediment and vitriolic Acid*, afforded by the filtered Fluid from the Solution of the precipitated Matter of twelve Gallons of Water, evaporated to Dryneſs; and ſix Grains of *Magneſia-Glauber Salt*, were boiled a ſhort Time in half a Pint of Snow-Water, then ſtrained, and the filtered Liquor evaporated to Dryneſs; whereby twelve Grains of Cryſtals of much the ſame Figure as, but of a much more bitter Taſte and more ſoluble than the former, were produced. The Sediment left upon the Filter was then boiled a little a ſecond Time in eight Ounces of Snow-Water, filtered, and evaporated as before; by which Means, ſeven Grains of a cryſtallized, rather bitter, ſlowly ſoluble earthy Salt was procured.

The Colour produced by the Addition of *Galls* to *recent* Solutions of Sediment, indicated the Exiſtence of *Iron*, or other Metal; but the Want of this Colour, upon ſome Occaſions, when the Solution had ſtood ſome Time, the tranſient Colour produced by phlogiſticated Alkali, and the light *gray Sediment* precipitated by Alkali (*u*), denoted, that theſe Metals were either there in accidental Portions of Solutions, or depended upon ſome Circumſtances with which we are not acquainted; or, that Galls are a fallacious Teſt of Iron (*x*). At any Rate, the very equivocal Signs of even a moſt minute Portion of Metal,

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(*u*) "Si quelqu'un avoit trop de peine à préparer mes Lèſſive Alcaline de ce Sel Alkali fixe avec le Sang calciné, il peut s'en tenir à une Lèſſive de cendres gravelées ordinaires pour faire la Precipitâtion de l'Extraît des Terres Calcaires par le Moyen de l'Eſprit de Vitrìol; il lui fournira un precipité Martial d' un *jaune d'Ochre* qui s' arrêtera au Fond du Vaſe; & en continuant à la traiter de la Maniere ſusdite, il ſera Témoin des mêmes Circonſtances."—(Margraaf, Opuſcules Chymiques, Tom. II. p. 68).

(*x*) Mr. *Boyle* ſays, Galls are neither of that extenſive Uſe, nor Certainty, for the Diſcovery of Iron, or other Metals, that is imagined; for Arſenic cannot be detected by this Means in Water; and green Vitriol, mixed with a large Quantity of Copper, only turns muddy or opaque, with Galls; and *Saccharum Saturni*, produces no Colour with this Subſtance. Solutions of Gold in *Aqua Regia*, of Mercury in Aqua Fortis, and Lead in nitrous Acid, produce no Colour with Galls: But volatile ſulphureous Acid, alone, or with ſome of theſe Metals, produce Colour with Galls. In another Place, he ſays, *Saccharum Saturni* produces ſome Colour with Galls, but ſulphureous Acid ſtrikes Colour immediately; and other Bodies, ſuppoſed to be Iron, turn black or purple with Galls, independent of that Metal.

in a Solution that muſt neceſſarily contain the metallic Matter of upwards of eighty Gallons of Water, juſtify the Concluſion, that *this Water either contains no Metal, or an exceedingly minute Quantity indeed*; and that this Portion depends perhaps upon certain Circumſtances of the Solution of abſorbent Earth with which we are unacquainted.

Theſe Appearances with Galls being inexplicable, I was led to perform a Variety of Experiments, that informed me of many Things altogether new, curious, and, perhaps, important. The principal of theſe I ſhall relate, after concluding my Obſervations on this Experiment (*y*).

The preceding Experiment, I think, deciſively proved, that this Water contains *no Magneſia, or any abſorbent Earth*, excepting calcareous Earth, at leaſt that is diſcoverable in the Sediment formed by decompoſing earthy Salts from 70 or 80 Gallons of Water. There was indeed in the Solution of the Sediment from the twelve Gallons, a more than uſually bitter Taſte than is perceived

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(*y*) I propoſed to expoſe the Matter precipitated by Alkali from the filtered Solution of an Ounce of *Sediment* in the vitriolic Acid, and the like Solution of the other Parcel of Sediment, to the Action of Phlogiſton; which would deciſively aſcertain, whether a viſible Quantity of Iron, or other Metal, be contained in more than 80 Gallons of Water; but I am prevented performing this Experiment for the preſent; and other Appearances, taken together, are ſufficiently concluſive, that Buxton-Water contains no Iron or other Metals.

from calcareous Earth combined with vitriolic Acid, which might indicate a ſmall Portion of Epſom Salt; but, if even a ſmall Portion of this Subſtance could be demonſtrated, upon this Occaſion, I ſhould rather ſuppoſe it aroſe from the Decompoſition of the Alkali (z) employed to precipitate the Sediment, than from any Magneſia contained in the Water.

Appearances on the Addition of Powder of Galls to Solution of abſorbent Earths, and Alkalies in Acids.

Calcareous Earth of any Kind, particularly Chalk, of various Parcels; the *Sediment* procured from Buxton-Water, or common Spring-Water, by adding fixed Alkali, as deſcribed in Exper. XII. and various Parcels of *Magneſia alba*, with a Variety of Specimens of very diluted vitriolic and muriatic Acids, added to nearly ſaturate them, to exactly ſaturate them, or to rather more than ſaturate them, when *recently diſſolved*, on the Addition of Galls of various Sorts previouſly powdered in a Marble Mortar, always produced inſtantly, or in a few Minutes, *Colour*; which was *black*, various Shades of *blue*, *green*, *purple*, and *pink*; but calcareous Earth which had been *long combined* with vitriolic Acid, and then diſſolved in Water, or Solution of native Gypſum, did *not produce a Colour* upon the Addition of powdered Galls, either without, or along with, fixt Alkali.

(z) Several Chymiſts, as before obſerved, notice the Converſion of fixed Alkali, by Dilution, &c. into Magneſia.

When a Colour was, by this Means, produced, the *Kind* and *Shade* of it appeared to depend upon the Quantity of Acid, and might be varied accordingly; ſo when the Colour was *black*, by adding a very ſmall Quantity of Acid more, it might be changed blue; by a little more Acid a light blue or deep purple; by ſtill more, a light purple; and by ſtill more, pink; and ſo on until the Solution was colourleſs, or only a tranſparent Amber Brown, not depending upon any Thing but the Solution of Galls in Water.

If the Solution had, on being firſt made, beyond a certain Quantity of ſuperabundant Acid, ſo as to prevent the Appearance of Colour with Galls; or, if the Colour after being produced was deſtroyed, by adding too much Acid, *Colour* might be made appear, or reproduced, by gradually adding Alkali of any Kind, or abſorbent Earth of any Kind, ſo as to nearly ſaturate the ſuperabundant Acid: Which *Colour* might be again *deſtroyed* by adding freſh Portions of Acid, and again produced on adding Alkalies or abſorbent Earth; and in this Manner, Colour of any of the above Kinds and Shades might be produced and deſtroyed at Pleaſure.

The Fluid poured off from a Quantity of vitriolic Selenites, after a recent Solution of calcareous Earth in diluted vitriolic Acid, produced Colour upon the Addition of Galls. The ſame Effect is commonly produced by a ſmall Quantity of boiling Water, poured a ſecond Time to diſſolve a Part of this ſelenitic Maſs; and by a third, and ſometimes a fourth Solution of it in Water: But after ſeveral Solutions have been made by a ſmall Quantity of Water, the Maſs of vitriolic Selenites, from which they have been produced, ceaſes to give Colour when diſſolved in Water; although as large a Portion of this Subſtance be obviouſly contained in the Solutions that do not, as thoſe which did, produce Colour.

When a Maſs of vitriolic Selenites, after repeated Affuſions of Water, has ceaſed to produce Colour, by Galls added to the Solution of it in Water; ſuch a Solution may ſometimes be made to yield a Colour, by adding *fixed vegetable Alkali* to this Solution with powdered Galls; which Effect alſo ceaſes, after a few further Solutions in Water.

When the Solution of a Maſs of vitriolic Selenites has ceaſed to afford Colour with Galls alone, and alſo with the Addition of fixed Alkali to this Solution and Galls; if this vitriolic Selenites be decompoſed by Alkali, and the precipitated calcareous Earth be re-diſſolved in vitriolic Acid, Solutions of this Compound, recently made, in Water, will produce Colour as before, with Galls, either with or without Alkali; and ceaſe to yield it a ſecond Time in the Manner above-mentioned, but may again be produced and deſtroyed as before, as often as we pleaſe, till the whole Maſs be diſſolved in Water.

The *Sediment* left after Evaporation of the Fluid poured off from the Compound of vitriolic Acid and Quicklime; and from the Compound of the ſame Acid, and the *Matter precipitated* by Alkali from Buxton-Water, re-diſſolved in Water would always, either immediately, or on the Addition of Alkali, produce Colour with Galls; even when before this Evaporation, Solutions of theſe Subſtances produced no Colour with Galls alone, Solution of the Sediment of them, left after Evaporation, produced Colour with Galls, upon the Addition of Alkali; provided, however, Colour could be produced before the Evaporation, either without or with Alkali, but not otherwiſe, which appears to be a curious Fact.

If to *muriatic Selenites, recently compoſed,* vitriolic Acid be added to decompoſe this Solution, and form vitriolic Selenites, and the muriatic Acid be waſhed, or poured off, ſo as to leave this Subſtance ſaturated without any, or with but a ſmall Quantity, of ſuperabundant Acid; upon the Addition of *Galls* to a Solution in Water of this Compound, Colour may be produced, without, or certainly with, the Addition of *Alkali.*

Neither the Acids diluted with Water, nor abſorbent Earths, nor Alkali, nor Compound of Alkali and Acid, would produce Colour with Galls; but when a very ſmall Quantity of Iron was added to Alkali, it produced Colour with Galls, when diſſolved in vitriolic Acid and Water.

The Alkali uſed, was obtained by deflagrating Nitre; alſo that procured by the chymical Analyſis of Vegetables.

Extremely dilute Solutions of Copper, Zinc, and Iron, mixed with ſaturated Solution of vitriolic Selenites in Water, produced, with Galls, according to the Degree of Dilution, *black*, *white*, *purple*, *blue*, and *red* Colours; but the Species of Metal could not be diſtinguiſhed by the Colour ſtruck with Galls, nor when the Galls were added to merely dilute Solution of theſe Metals in Water.

The learned and ingenious Biſhop of Llandaff, (ſee *Chymical Eſſays*) found one Grain of green Vitriol diſſolved in 15 Gallons of Water, produced Colour with Galls; and ſuppoſing half a Grain of Iron to be contained in this Quantity of Vitriol, then half a Grain of this Metal is diſcoverable in 30 Gallons of Water.

A dilute Solution of *Alum* with Galls, produced immediately a turbid Fluid, that on ſtanding, exhibited white Clouds, ſuſpended in a watery tranſparent Fluid.

I found a very ſmall Quantity of Calx of Iron, as well as of Copper and Zinc, with a large Quantity of calcareous Earth, might be diſſolved by vitriolic Acid, and yet not made appear by Galls added to the filtered Liquor, until fixed Alkali ſhould be added to the Galls; and that then a coloured Precipitate would be made, but the Metals were not diſtinguiſhable by any particular Colour of this precipitated Matter.

Neither found animal Mucilage diſſolved in vitriolic Acid and diluted with Water, nor putrid animal Mucilage diluted with Water, as putrid Serum of human Blood, produced Colours with Galls, either with or without the Addition of Alkalies.

Sal Ammoniac diſſolved in Water, produced no Colour on the Addition of Galls.

It is probable, that the Solution of abſorbent Earths in other Acids beſides vitriolic and muriatic Acids, have the above-deſcribed Property of producing Colour with Powder of Galls.

The *turbid Water*, after ſtanding ſeveral Days upon the Sediment of the twelve Gallons of Water (ſee p. 196) before it was evaporated, in Quantity about a Pint, became fetid. To a little of this turbid and fetid Liquor were added a few Grains of Powder of Galls: At firſt there was no Alteration, but in an Hour or two the Water became *ſtill more turbid, thicker, and whitiſh.* In twelve Hours it was *greeniſh at the Top, and under* *this it was milky*, and depoſited *a whitiſh Sediment*. By ſtanding longer this Fluid became *curdy*, and of *a purpliſh Hue*; the middle Part was *milky* and *thick*, and the Top was of a *dark blue Colour*. Upon adding two Drops of vitriolic Acid to the Water in this State, it was changed to *the Colour of red Port, was thinner, and half tranſparent*.

The very ſame Appearances were exhibited on a Repetition of this Addition of Galls to a freſh Portion of this turbid Liquor; and likewiſe with Water, added ſeveral Times to this Sediment only rendered turbid without being fetid.

I have found, that the above Liquor with powdered Galls, ſometimes, for perhaps twelve Hours, had no Effect, but would then turn muddy and of a horny brown Colour; and in a Day or two would have a Ring of a blue or black Colour. This I look upon, from various Obſervations, to be the ſmalleſt Effect of Iron or ſome other Subſtance which is precipitated by Galls that is viſible.

Calces of Iron, Zinc, and Copper, produced no Colour when they had been infuſed in Water and filtered; but Water containing a Sediment of Calx of Iron agitated with Powder of Galls, occaſioned a black Colour.

Dr. *Fordyce* obſerved in his chymical Lectures, that fixt Alkalies in a cauſtic or mild State, expoſed with Phlogiſton of animal or vegetable Subſtances, as with Charcoal or Blood, to a red

Heat, form phlogiſticated Alkali; from which Subſtance a Matter may be precipitated of a *blue Colour*, called *Pruſſian Blue*;—that as green Vitriol was employed to precipitate this Subſtance in the Manufactory of Pruſſian Blue, the blue Colour was ſuppoſed to depend upon *Iron*;—that *this blue Matter may be precipitated of a blue Colour by vitriolic Acid without Iron*;—that *the ſame Matter may be precipitated by other Acids, but then it is not of a blue Colour*; and that this Subſtance, free of Iron, has not been properly examined.

The Reſult which I ſhall relate of a Repetition of theſe Experiments, was rather different from that of my learned Friend; as muriatic Acid likewiſe occaſioned a blue Precipitate to be thrown down, upon being added to phlogiſticated Alkali.

To phlogiſticated alkaline Lixivium, was added diluted *vitriolic Acid*, which occaſioned an Effervеſcence *without producing Colour till nearly ſaturated*; when, as well as when rather more than ſaturated, there was a *tranſparent Fluid of a Pruſſian blue Colour*. Upon adding more of the alkaline Ley it became *colourleſs*, and had the *Colour again reſtored* upon adding more Acid. By ſtanding, it depoſited a *blue Powder like Pruſſian Blue*.

The above Appearances continued, during the Addition of much more vitriolic Acid than was ſufficient to ſaturate the alkaline Lixivium; which ſuper-ſaturated Alkali, on ſtanding, depoſited a Sediment of *a Pruſſian blue Colour.*

Nitrous Acid poured upon this alkaline Lixivium produced a turbid Fluid, which after ſtanding had a *thick*, *copious*, *yellow Sediment.*

Phlogiſticated alkaline Lixivium, and alſo Lixivium after detonating Nitre, with *muriatic Acid*, produced the ſame *blue Colour* and *Precipitate* as above-mentioned.

Nitrous Acid and Lixivium of deflagrated Nitre produced only a *white turbid Fluid*, that on ſtanding depoſited a *copious white Sediment.*

Solution of mild fixed Alkali with Powder of Galls, and Spirit of Vitriol to ſaturate this Alkali, produced no Colour till it had ſtood an Hour, when *a blue Colour appeared.*

Calcareous Earth with Spirit of Vitriol to ſaturate it, and *Powder of Galls*, produced a *pink Colour of the Chalk while diſſolving* ; and when the Solution was finiſhed, the *Sediment was, towards the Bottom, tinged of a pinkiſh Colour*, and the Fluid above was tranſparent and Amber-coloured. To ſome of this tranſparent amber Fluid I added Solution of *common* mild Alkali, which changed it immediately *muddy*, *thick*, and *purple-coloured.*

This phlogiſticated fixed Alkali here employed had the Odour preciſely of volatile Alkali, and was made by calcining common fixed vegetable Alkali with dried Blood.

In various Parcels of Potaſh, I have ſeen ſeveral Parts of it coloured of a Pruſſian blue Colour; but it is with me a Queſtion, to what this Colour is owing: It may be a Matter of the ſame Kind as that precipitated by vitriolic Acid from phlogiſticated Alkali.

The general Obſervations, that may be made upon the preceding Reſults, are

1. That a coloured Matter, apparently of the ſame Kind as Pruſſian Blue, may be precipitated from Compounds of abſorbent Earth and any Acid by Galls alone, or by Galls and fixed Alkali; which is not only a new Fact in Science, but may be of immediate Application to the Arts; becauſe it ſhows various Methods of effecting the ſame End.

2. That this blue Precipitation cannot be made from Combinations of abſorbent Earths and Acids long formed.

3. That as this Precipitation of coloured Matter may be produced from Solutions of vitriolic Selenites in Water repeatedly made till the whole Compound is diſſolved in Water; provided after it has ceaſed to yield a coloured Precipitate, the Compound be decompoſed by Alkali and again diſſolved in Acid, this Matter is either a Production of the whole Compound by Galls, or it is diffuſed through every Part of the Compound of which a ſmall Portion only can be precipitated at a Time.

4. That this *coloured Subſtance* cannot be produced, in general, merely from recently-made Combinations of Acid with Alkali or other Matters in general, but only from Compounds of abſorbent Earths and Acids, excepting upon ſome Occaſions.

5. That the Principle upon which this Precipitation is made, is not underſtood, but conſidering the Effect of Subſtances, containing Phlogiſton looſely combined, in producing *black Colours* with Galls, as volatile vitriolic Acid, fetid Water containing calcareous Earth, phlogiſticated Alkali, or, perhaps, fixed Alkali converted into volatile Alkali by uniting it to Phlogiſton, it may perhaps be reaſonably conjectured, that *Phlogiſton, not Iron, is eſſentially neceſſary to the Production of Pruſſian Blue.*

6. That phlogiſticated Alkali, as well as Galls, is a fallacious Teſt of Iron; for Iron may exiſt and not be diſcovered by theſe Subſtances, or not till fixed Alkali be added, and the colouring Subſtance, ſaid to be peculiar to Iron, appears where we have not the moſt diſtant Suſpicion of the Exiſtence of this Metal; or if this coloured Matter be compoſed of Iron, then this Metal exiſts in Subſtances, and under Circumſtances not before pointed out or underſtood. And this ſuggeſts, that *Alkali added to Galls and any fluid Mixture, is a more delicate Teſt of Iron than Galls alone.*

It is much to be deſired, that ſome Perſon would collect a ſufficient Quantity of this precipitated Matter and inveſtigate its Properties; particularly, whether with Phlogiſton it may be converted into Iron, or any other metallic Subſtance, and with Acid form a metallic Salt.

Exper. XV. Solutions were made of ſix Sorts of Soap, viz. Spaniſh, common Ball, Turpentine, Caſtile, Almond, and ſweet Soap, in eight or ten Times their Weight of diſtilled Water, with which they formed viſcid, pearly-coloured, uniform Fluids.

The Almond and Spaniſh Soap were viſcid Mucilages, but the Ball and Turpentine were Jelly-like; and the Caſtile Soap was a much more ſtiff Solution than the other Soaps with this Quantity of diſtilled Water. All theſe Solutions changed bright Graſs-Green, on being mixt with Syrup of Violets; but every Thing which changes Syrup of Violets green is not Alkali, although Alkali always changes blue vegetable Juices green.

A little of each of the above Solutions was agitated with ſixty Times its Bulk of *Buxton-Water* freſh from the Well, with the ſame Bulk of this tepid Water *after boiling*, both hot and cold; and with this Spring-Water, which had *ſtood in the open Air* till it was cold.

The Solution of Spaniſh, Almond, and ſweet Soap united with Buxton-Water, under the above Circumſtances, without the leaſt apparent Decompoſition. The Solution of Caſtile Soap was partially decompoſed, and that of Ball and Turpentine Soap were wholly decompounded, by being agitated with Buxton-Water. Sometimes Buxton-Water when cold lathers well with Caſtile Soap, but decompoſes it when hot.

Theſe Solutions of Soap were alſo agitated with common *Pump-Water*, and with Solution of vitriolic Selenites in *diſtilled Water*, and the ſame Effects, or nearly the ſame, enſued as with *Buxton-Water.*

Any Compound of Acid and Earth, or Acid and Calces of Metals, diſſolved in Water, will decompoſe Soap, excepting calcareous Earth; which laſt Subſtance does not prevent Water forming uniform Solutions with Soap, becauſe *Gas is an Acid that has a ſtronger Attraction for Quicklime, than for the cauſtic Alkali combined with the Oil forming Soap.*

Any *Acid* combined with Water, as volatile ſulphureous Acid, and Gas (*a*), decompoſes Soap: And any *neutral Salt*, although it does not decompound the Compound of Oil and cauſtic Alkali,

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(*a*) Mr. *Cavallo*, ſays Dr. *Prieſtley*, (Exper. and Obſervs. Vol. I. p. 31.) alſo frequently found Water impregnated with Gas, does not diſſolve Soap ſo readily as without it; but that upon repeating the Experiment with Mr. Fontana, no Difference was obſerved, between Water with, and Water without, Gas.

Upon Repetition of this Experiment, I found diſtilled Water decompoſed Soap impregnated with Gas: But there are, frequently, Circumſtances accompanying the ſame Experiment, that occaſion a different Reſult.

kali, when diſſolved in Water prevents Water ſaturated therewith from uniting with Soap (*b*).

A Spring-Water that decompoſes Soap, is called a *hard Water*; and the beſt known Signs of this Decompoſition are the curdling of the Water upon mixing the Soap therewith, its not forming a ſmooth Mixture with Soap when employed for waſhing the Skin of the Hands or Face, and its not making an effectual Solution for removing Filth from Linen.

Spring-Waters that are *hard*, from whatever Subſtance, excepting the Compound of vitriolic Acid and Quicklime, or what is commonly known by the Appellation of gypſeous Earth or Plaſter-Stone, have ſo much, or ſo diſagreeable a Taſte, and alſo, frequently, ſuch a Smell, as to prevent their being employed for culinary Purpoſes: But Springs are ſometimes, although but rarely, ſo highly ſaturated with gypſeous Earth, as to have a ſlightly nauſeous Taſte. In general, it is contained in ſuch Proportions, that the greateſt Number

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(*b*) Dr. *Fordyce*, in his Chymical Lectures, aſſerted, that Solution of Soap in Water, was decompoſed by neutral Salts and Alkali; but upon mixing ſaturated Solution of fixed vegetable Alkali, and alſo Solution of vitriolated Tartar with the Solution of Soap, they formed uniform Mixtures: However, I probably did not effect the Decompoſition, for want of Attention to proper Circumſtances; or, probably, the ſmall Quantity of ſuch a neutral Salt, as vitriolated Tartar, diſſolved in Water, is not ſufficient for this Purpoſe.

ber of the moſt pleaſant taſted Springs in this Iſland, are *hard Waters* from this Subſtance.

As Buxton-Water has neither Taſte nor Smell; as it decompoſes Soap, too, equally after boiling, as before Expoſure to Heat, we conclude, that *its Hardneſs is occaſioned by the general Cauſe of hard Waters, namely, a Solution of vitriolic Selenites.*

There was no apparent Decompoſition with the Solution of Spaniſh Soap, i. e. Compound of cauſtic foſſil Alkali and certain expreſſed Oils of Animals; nor with Almond Soap, which, I believe, is expreſt Oil of Almonds and cauſtic foſſil Alkali; or with ſweet Soap, which is expreſſed Oil of Fiſhes and cauſtic vegetable Alkali; not only becauſe the Union is more cloſe and perfect between the Elements of theſe Compounds, and therefore ſuch as requires the Aid of particular Circumſtances in Order to effect their Decompoſition, but on Account of the great Viſcidity of the Solution of the Part of theſe Soaps not decompoſed, the Oil of the Part decompoſed is diffuſed throughout the Solution.

The Decompoſition was very evident with the Solution of Ball-Soap, the Compound of fixed vegetable cauſtic Alkali and expreſt Oil found in the adipoſe Membrane of Quadrupeds; and Turpentine Soap, which is, I am informed, this laſt Compound with a Portion of eſſential Oil or Reſin; and in general, this Decompoſition was evident with Caſtile Soap, or cauſtic foſſil Alkali, ſaturated with expreſſed Oil of Quadrupeds.

Sometimes a *hard* Water, with a Portion of Soap uſed for waſhing the Hands, is not decompoſed, becauſe a Quantity of ſuperfluous Alkali adhering to the Soap decompoſes the vitriolic Selenites. The above green Colour of Solution of Soap and Syrup of Violets was, I think, rather occaſioned by the Soap than any ſuperfluous Alkali; for a green Colour is but an equivocal Sign of Alkali.

As theſe three laſt Soaps are the ordinary Sorts in Uſe for culinary Purpoſes, we can underſtand why Buxton-Water is avoided by Waſhers of Linen for diſſolving Soap; becauſe, before this Water diſſolves this Subſtance, the vitriolic Acid of the Gyps muſt be ſaturated with the Alkali of the Soap. This having taken Place, the Water unites with the Soap not decompounded; but, as a Portion of Soap is thus deſtroyed, and the expreſſed Oil as well as Earth ſuſpended in the Water in Conſequence of the Decompoſition, is liable to ſoil and injure certain Things of a delicate Colour and Texture to be cleanſed, it is both improper and too expenſive, to uſe this tepid Water for cleanſing Subſtances from Dirt by Means of dilute Solutions of Soap.

As the finer and ſpecifically heavier Sorts of Soap, as Spaniſh and Almond Soap, &c. are commonly uſed for waſhing the Skin of the Face and Hands; which, although partially decompoſed, form ſuch viſcid Solutions, as that this Effect is not perceived, and the Deſtruction of Part of the Soap is here not an Object of Expence, we can ſee the Reaſon why Buxton-Water is in ordinary Uſe for this Purpoſe. However, the End is not anſwered ſo well, upon this Occaſion, as by ſoft Waters; for, it is obſerved, that not only Linen is waſhed of a better Colour, but alſo that the Hands and Face are rendered whiter by Solutions of Soap in Water that does not occaſion any Decompoſition at all, as in Snow, Rain, or diſtilled Water, than in common hard Waters.

The Subſtance occaſioning the *Hardneſs* of Buxton-Water, is further ſhewn by *the Means of rendering it ſoft.* It appeared from various Trials, that with a leſs Quantity than a Grain of fixed vegetable Alkali to an Ounce or 480 Grains of Buxton-Water, or at leaſt, with leſs than half a Drachm of this Salt to a Quart of this Water, it was not rendered perfectly *ſoft*, or capable of forming an uniform Mixture with the Solution of Ball-Soap above-mentioned. The Water was rendered ſoft by this Subſtance, becauſe the vitriolic Acid of the Gyps united with the Alkali added, and formed vitriolated Tartar, while the Quicklime of the Gyps combined with the Gas of the mild Alkali, and formed calcareous Earth; but as neither vitriolated Tartar in ſmall Quantity,

tity, nor calcareous Earth, prevents the Union of Soap with Water, this Fluid, after the Addition of a ſufficient Quantity of mild Alkali, united with Soap without occaſioning the ſmalleſt Decompoſition.

This is the Principle, upon which may be explained the moſt frequent Method of rendering Waters *ſoft*, by the Addition of Aſhes of Vegetables or Potaſh, in Situations that are at a Diſtance from *ſoft* Waters afforded by Springs, or Rivers; and where, perhaps, Water is not plentifully precipitated in Rain or Snow; or where the Cuſtom does not prevail of collecting Rain and Snow-Water. The fixed vegetable Alkali is the Subſtance contained in theſe Aſhes, that renders Water *ſoft* in the Manner above-related.

Thoſe who are deſirous of employing Buxton-Water as a *ſoft* Water, are furniſhed, by the above Experiment, with the cheapeſt Method or ſmalleſt Portion of Alkali that will effect this Purpoſe. After adding the Alkali, the Solution ſhould ſtand at leaſt 24 Hours, and then be decanted or filtered for Uſe.

Buxton-Water may, perhaps, alſo be rendered *ſoft*, by two other Methods employed by Nature, namely, *Expoſure to the Air of the Atmoſphere*, and *Evaporation*.

Firſt, It is a known Fact, that all, or the greateſt Number of Rivers, are *ſoft* Water; but, that the Springs by which they are formed are, for the moſt Part, of *hard* Water. I have more than once traced pretty large Rivers of ſoft Water to their Source in *hard* Spring-Waters, and found this Quality to diminiſh according to the Extent of their Courſe, and Expoſure in broad and ſhallow, or narrow and deep Channels to the Atmoſphere. Accordingly the *Springs* were found *hard*; a *ſhallow Stream* formed by many of theſe Springs was *leſs hard*; a *Rivulet*, from ſtill more of theſe Springs contained Water which had *this Quality in a leſs Degree* than the Brook flowing into it; and by the Time a large Body of Water, namely, a *River* was formed, by the Junction of numerous ſmall Streams, *ſoft Water* was found.

Soon after conſiderable Falls of Rain, or Snow, in the eminent Lands deſtined for the Origin of Springs, Rivers and even *hard* Springs are rendered ſoft by the Mixture of a large Quantity of Rain, or Snow-Water, that has not been impregnated with Selenites and other Subſtances in the ſubterraneous Paſſages of the Earth: But, upon other Occaſions, when Rivers or Rivulets of *ſoft* Water are evidently ſupplied by Springs of *hard* Water, the Change in the Quality of the Water is occaſioned by *Expoſure to the Air of the Atmoſphere*; the Effect of which is the ſame as upon dilute Solutions of earthy and metallic Salts; namely, to decompoſe them, and therefore to render *hard* Water *ſoft*. This Operation of Nature is imitated, by expoſing *hard* Spring-Water in Veſſels to the open Air, by which Means, its Quality of *Hardneſs* is diminiſhed. And this Change may be accelerated, perhaps, by *Expoſure to Heat*; for ſometimes by boiling, hard Waters are rendered *ſoft*; becauſe the Selenites is decompoſed by Heat: Sometimes, they are made *harder* by boiling; becauſe, this Salt is not decompoſed, and the Solution of it is more concentrated by having evaporated Part of the Water.

Secondly, The *hardeſt* Waters, after being converted into Vapour by Heat, or diſſolved in Air, and again brought into a fluid Form by Condenſation, or Precipitation, are perfectly *ſoft*; becauſe the ſolid Subſtances with which they were impregnated, and therefore Gyps, were not raiſed along with this Vapour. Hence Rain and Snow-Water are always perfectly *ſoft* Waters; and, excepting on Account of the Subſtances they meet with in their Paſſage through the Atmoſphere, are as pure, as well as *ſoft*, as diſtilled Water. *Diſtillation* is ſcarcely in Uſe for rendering Water *ſoft* for culinary Purpoſes.

The tepid Springs of Buxton never vary in their Quality of Hardneſs by Rains, Drought, or any other Cauſe.

Having ſhown then, that the tepid Springs of Buxton belong to the Claſs of *hard* Waters, and that the Subſtance on which this Quality depends is the ſame as that of *hard* Waters in general; we ſhall be able to account for ſome known Effects in domeſtic, or culinary Uſes, and to infer other Effects dependent upon this Subſtance.

1. The tepid Waters of Buxton are in ordinary Uſe, as well as thoſe of Matlock, for making *Infuſions of Teas.* The *Flavour* and *Colour* of the Infuſion of theſe Subſtances is more agreeable in Buxton-Water than in common Spring or River-Water; which may be accounted for by conſidering, that the Proportion of vitriolic Selenites is not ſo great in Buxton-Water, as in many *hard* Springs, therefore either to communicate a Taſte, or occaſion too ſparing a Solution; or, like Water that contains none, or in ſo ſmall a Quantity as not to impart the agreeable Colour peculiar to Infuſions of Vegetables in dilute Solutions of vitriolic Selenites. But, like all other hard Waters, a greater Quantity of Tea is neceſſary to make an Infuſion in this tepid Water of a given Strength, than in *ſoft* Water; becauſe, it ſeems, Water containing vitriolic Selenites, does not ſo readily or ſo effectually diſſolve vegetable Subſtances as Water without this Impregnation.

On the Power of Solution being different in different Waters, various Effects in the Practice of Arts depend. For *Dying*, *Bleaching*, *Tanning*, &c. *ſoft* Waters are preferred, or are eſſentially neceſſary. In *Dying*, the Excellency of the Colour is ſaid, upon ſome Occaſions, to depend upon the Water peculiar to certain Situations. *Boerhaave* ſays, the Water near *Leyden* is peculiarly proper for Dying, and producing finer Colours than other Places. In general it is obſerved, that Waters which have ſtood long, putrefied, and been filtered through Sand, are the beſt for Dying; becauſe they extract the fineſt Colour, and to the greateſt Advantage; and in ſhort, for Solution in general, the lighteſt and *ſofteſt* Waters are preferable: therefore, Buxton-Water is improper for theſe Purpoſes.

In the waſhing of Deal-Floors, *hard* Water is is ſaid to have the Effect of producing a blackiſh Colour. For *tempering* of Steel *hard* Water is preferred. *Plants* watered with *hard* Water are liable to be injured or killed; therefore, Gardeners expoſe it to the open Air ſome Time before uſing it.

Particular Brooks or Rivulets being adapted particularly to certain Fiſhes, depends as much upon their Impregnation with calcareous Earth or other earthy Salts, as any other Cauſes.

2. The Water of theſe tepid Fountains is rarely employed for *brewing Malt-Liquors*, although, according to Information, it anſwers well for this Purpoſe; probably, not becauſe the *Ale* would not be ſo good in *Quality*, but becauſe it would not diſſolve ſo compleatly the Sugar of Malt, which is to be fermented into that Species of Wine called *Ale*; and conſequently, not afford vinous Liquor in ſo great *Quantity* as Solutions in *ſoft* Water. It is, I find, a Cuſtom in many

Places, to employ for brewing, equal Parts of *ſoft* and *hard* Waters; which ſeems, as if a dilute Solution of Selenites anſwered better than Water entirely without this Subſtance. Alſo hard Waters are preferred for Wines intended to be long kept. But the peculiar Excellency of the *Thames-Water* for making Porter, probably, does not depend entirely upon its *Softneſs* as a River-Water, and conſequently Want of Selenites, but upon ſome other Qualities not underſtood.—Does it depend upon its containing ſuch a Proportion, viz. $\frac{1}{500}$ of its Weight of animal and vegetable Matter as to be fermentable of itſelf?

The *Spree-Water* uſed for brewing, *Margraaf* found contained in 900 Ounces, or 25 Quarts, four Drachms 15 Grains of calcareous Earth, 30 Grains of common Salt, a ſmall Quantity of alkaline Ley, and a Subſtance like Nitre.

3. The Buxton-Water is in Uſe for *coagulating Vegetables* in the boiling Heat of Water, where a *fine green Colour* and *Firmneſs* is wiſhed for, that certainly depend upon the vitriolic Selenites; and yet, I am told, a very dilute Solution of vegetable Alkali in Water, boils Vegetables of a fine green Colour: But where Colour and Firmneſs are not required, as I am informed, in boiling certain Roots, as Potatoes, Turnips, &c. *ſoft* Water is preferred. One of the Signs of Salubrity of Springs is taken from the Effects of them in coagulating Vegetables.—“ Ex iis quæ pon-

dere pares ſunt, Eo melior quæque eſt quo celerius & calefit & frigeſcit, quoque celerius ex ea Legumina percoquuntur."— *Celſus.*

As *hard* Waters even diluted with *ſoft* Water, impart a reddiſh or brown Colour to animal Mucilage boiled therein, inſtead of a white Colour when coagulated by boiling in *ſoft* Water; this tepid Water is, probably, not employed upon thoſe Occaſions in the Kitchen, where *Colour* is an Object, as of Rabbits, Fowls, Veal, &c. but where *Firmneſs* merely is required as in the boiling of *Fiſhes*, then hard Water is preferred. Likewiſe for Subſtances to be preſerved by Sugar or Acid, which are to be firſt boiled, *hard* Water is more proper. I believe, that if a Slice of Veal be put into a Cup of *hard* Water, and another Slice into a Cup of *ſoft* Water, on ſtanding, the Water of the latter will become reddiſh-coloured, and the Fleſh be ſoft, while the Water in the former is almoſt *colourleſs*, and the Fleſh *hard*.

5. This tepid Water will frequently not be employed in Summer Time, merely for common Drink, or diluting Wine, becauſe of its Temperature ſo much exceeding that of other cold Springs of *hard* Water; and, becauſe it cannot, in general, by mere Expoſure to the Air, be cooled to the Degree of Springs of cold Water, or about 48°; but in cold Weather, or in the Winter Seaſon, after cooling it in the Atmoſphere,

ſphere, it may be uſed for common Drink, as well as any ordinary Spring-Water.

A pleaſant Spring, much uſed at *Berlin*, for drinking, according to *Margraaf*, contained in 100 Quarts, each of which held 36 Ounces, 1 Ounce 2 Drachms and 15 Grains of calçareous Earth, 7 Grains of Gypſum, 2 Drachms and a half of common Salt, 8 to 10 Grains of Nitre, and 30 Grains of Mother-Ley of Salt-Petre.

II. AIR.

Exper. XVI. An eight Ounce wide-mouthed Phial, containing about a Drachm Meaſure of *vitriolic Acid*, was filled with Buxton-Water, by immerſing it in the Well; which, being withdrawn the Inſtant it was filled, was inverted in a Baſon of this tepid Water, and placed near a hot Fire. In the Space of a Night, about half a Drachm Meaſure of permanent Vapour, apparently *Air*, was collected at the Top of the inverted Bottle; and while this Quantity was collecting, the Water *ſparkled* much more with *bright Bubbles* than this tepid Water inverted and placed in the ſame Expoſure, without the Addition of any Acid, and which did not ſeparate more than about two-thirds of this Quantity. On the Addition of Spirit of Vitriol to this tepid Fountain-Water of Buxton, the Number of Bubbles, that manifeſt themſelves ſpontaneouſly in Veſſels filled with it, is increaſed; and this increaſed Number of Bubbles, even takes Place on the Mixture of Solution of Metals in nitrous Acid, for other Purpoſes. It appears, that during the Union of Acid of Vitriol with this Water, *Air*, or ſome other permanent Vapour, combined with, or diffuſed throughout, this Fluid, was diſunited; as was manifeſt by its adhering to the Sides of the Veſſels, gradually collecting together, and riſing to the Top of an inverted Veſſel of this Water.

III. PHLOGISTON.

Exper. XVII. A Piece of Writing-Paper, that had been dipped in a Solution of *Saccharum Saturni*, and afterwards dried, was ſuſpended immediately over the Parts of Buxton-Bath where the Bubbles roſe ſpontaneouſly, and vaniſhed upon its Surface; but no Colour was induced in the Paper by this Expoſure.

A Maſs of *poliſhed Silver* was immerged ſome Time in this tepid Spring, but it was not tarniſhed by this Means.

I have found, that phlogiſtic Vapours, or Phlogiſton, riſing from various Subſtances, as from Animal Matter during the putrid Fermentation, tinge Paper that has been moiſtened with Solution of Sugar of Lead, ſuſpended over the Surface of them, of an Orange-Colour firſt, and afterwards of the Colour of Lead; and that a ſimilar Colour is produced on the Surface of Silver, by the ſame Means.

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As no Colours were produced in this Experiment, it is inferred, that no phlogiſtic Matter is contained in, or ſeparates from, this tepid Water.

Reſult of the whole of the preceding Experiments by Means of MIXTURE.

The Mixture of Subſtances with Buxton-Waters, inſtructs us, that they contain *no Acid*, excepting, perhaps, a ſmall Quantity of Gas, and *no Alkali*;—that they are impregnated with *vitriolic Acid combined with Quicklime*, forming vitriolic Selenites, but whether united with other Subſtances alſo, theſe Experiments do not make appear;—that they contain *muriatic Acid combined with ſome Subſtance*, but with what Kind of Matter is not aſcertained; and alſo *calcareous Earth*;—that it is extremely doubtful, whether they have any *metallic Salt*, but that, if they do contain any, it is Iron diſſolved, probably, in Acid of Vitriol, certainly not by Gas; and that they are impregnated with a *permanent Vapour*, which is probably Air, but *not with any phlogiſtic Subſtance*.

The Proportion of theſe Subſtances, diſſolved in Buxton-Water, to each other, and to the Water, doth not appear from theſe Experiments by Mixture; but from the Compariſon generally made, of the Appearances on Mixture with common Spring-Waters, it is probable, that they are not only the ſame Sort of Subſtances, but in Quantity not exceeding that which is uſually contained in ordinary cold Springs.

We ſhall next relate the Properties of this tepid Water of Buxton, that are made appear by Means of Heat.

SECTION III.

Containing Experiments to diſcover, by Means of HEAT, *the Properties of Buxton-Water.*

Exper. XVIII. I Propoſed to aſcertain by this Experiment, whether any, and what Quantity of *permanent Vapour* may be ſeparated by Heat.

A Tin-Pan was procured with an inverted Funnel, of the ſame Kind as that invented, deſcribed, and employed by the Hon. Henry Cavendiſh, for ſeparating Air from Rathbone-Place Waters (*c*). This Pan held 20 Pints, 16 or 17 of which, were contained under the Funnel.

It was filled at the Spring with the tepid Water of Buxton, and at the ſame Time a three Ounce wide-mouthed Phial quite full of this Water, was inverted over the Throat of the Funnel. During

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(*c*) See Phil. Tranſ. Vol. LVII. 1767. Veſſels for the Purpoſe of extracting permanent Vapour from Water, have been alſo contrived by Boerhaave, (ſee his Chymiſtry, tranſlated by Shaw) and by Abbé Fontana.—Phil. Tranſ. Vol. LXIX.

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the Space of five Minutes after this Pan was filled, and previouſly to its being placed upon the Fire, the inverted Bottle ſparkled with Bubbles that adhered to the Sides of it; and, about half a Drachm Meaſure of apparently permanent Vapour collected at the Top of this inverted Phial. After two Hours Expoſure to Heat, not exceeding 160° or 170°, about two Ounces and two Drachms Meaſure of apparently permanent Vapour were obſerved within the inverted Phial: And, as the Water ceaſed to ſeparate this Vapour during the Continuance of the Expoſure of it to this Heat, the inverted Phial was removed, and ſet to ſtand in a Saucer of cold Buxton-Water; where, in a few Minutes, the Bulk of Vapour diminiſhed to one Ounce and ſix Drachms Meaſure. After this Time, I found that a boiling Heat continued for two Hours and a half or three Hours, was required, in order to extricate the Remainder of the apparently permanent Vapour that was capable of being detached from this Bulk of Buxton-Water; and which contracted its Bulk on ſtanding in cold Water, much more than the former inverted Phial of Vapour. This apparently permanent Vapour roſe within the inverted Phial viſibly, in the Form of ſmall bright Bubbles, rather ſmaller, but as ſparkling as Bubbles of Air in Water.

After the Water ceaſed to ſeparate theſe Air-like Bubbles, and a boiling Heat was continued, it exhibited large Bubbles which roſe within the inverted Bottle, and there vaniſhed, without augmenting the Bulk of Vapour already collected, or remaining in the State of Vapour, excepting during the Ebullition. Theſe Bubbles might be produced till the whole Water was evaporated, and yet no further permanent Vapour be collected.

A Quantity of the above apparently permanent Vapour was procured by Means of this Tin-Pan, filled ſeveral Times with Buxton-Water; and, it was found, that each Panful of this tepid Spring afforded from *four Ounces to four Ounces and a half Meaſure* of this Vapour, when the Temperature of the ſurrounding Medium was about 54°, and the Atmoſphere was of its mean Degree of Weight.

If the inverted Phial of apparently permanent Vapour was only warm, when removed from the Pan into a Veſſel of cold Water, the Diminution in the Bulk of it was not conſiderable, and the utmoſt Contraction of which it was ſuſceptible, under the above Circumſtances, was effected in the Space of a few Minutes. But, when the inverted Bottle was hot at the Time it was carried from the Pan into the Saucer of cold Water, the Contraction in the Dimenſions of the apparently permanent Vapour was very conſiderable, and required ſeveral Hours Expoſure, under the above related Circumſtances, before this Contraction entirely ceaſed. After this Time, it varied little in

Bulk while ſtanding in Water for a Day or two, provided the Temperature and Weight of the Atmoſphere remained nearly in the ſame State.

It is worthy of Notice, that however hot the inverted Phial of Vapour was at the Time of removing it from the Pan; and however great the Diminution of its Bulk would have been under the above-related Circumſtances, the greateſt Degree of Contraction of its Dimenſions might be produced in the Space of a few Minutes, by tranſferring it through a large Bulk of cold Water from one Phial into another.

Buxton-Water, after being deprived of apparently permanent Vapour by Heat, in the Manner above-deſcribed, was quite clear, and a white earthy Matter was found adhering to the Sides of the Pan, Funnel, and Outſide of the inverted Phials.

The inviſible Subſtance, by the above Means collected, and contained in the inverted Phials, was varied readily and evidently in its Bulk by Preſſure; as appeared by merely immerſing in a very deep Veſſel, as a Tub of Water, a Tube filled with this Vapour to a certain Mark while it ſtood inverted with the End juſt below the Surface of Water. In Conſequence of this Immerſion, the Water was ſeen to riſe within the Tube above the Mark, or the Column of Vapour within the Tube was ſhortened, and might be reduced to its former Dimenſions, when the Water was made to fall within the Tube to the Mark, by elevating it to its former Poſition, or ſo that the open End of it juſt touched the Surface of the Water. Many other Appearances ſhewed the Variation of the Dimenſions of this Subſtance, to be according to the Degree of Preſſure to which it was expoſed; and the Bulk of it was as ſenſibly altered by different Degrees of Heat.

Deduction. The Subſtance procured from Buxton-Water by Heat in the above Experiment was a *Vapour*; becauſe it was *elaſtic*, and readily and conſiderably varied *in its Bulk*, according to the Temperature and Weight of the ſurrounding Medium; alſo becauſe it was *inviſible* in a ſmall Quantity viewed together, which is a peculiar but not eſſential Property of Vapour. From its retaining the State of Vapour in various Temperatures of the Atmoſphere, it belongs to the Claſs of *permanent Vapours*; but concerning the Sort of Vapour we can only infer, that it is not Gas, or any other Vapours which are readily, or at all ſoluble in Water; nor any of thoſe that have a Smell, as that permanent Vapour called Hepatic Air.

Exper. XIX. I propoſed, in the next Place, to determine the *Kind* of permanent Vapour procured by the laſt Experiment.

To *two* Meaſures of this permanent Vapour, were added *one* Meaſure of nitrous Gas; which being agitated in a white Flint Phial, immediately produced a turbid Orange-coloured Appearance, and ſome Degree of Heat, for a few Seconds; the Mixture then became tranſparent, and was ſenſibly diminiſhed in Bulk. After ſeveral Mixtures of this Sort, with different Parcels of permanent Vapour, had ſtood two or three Days, they were transferred into a Tube for meaſuring the Bulk of permanent Vapours. The three Meaſures were always found diminiſhed, but in various Degrees; in ſome Inſtances meaſuring two Meaſures and one-eighteenth, and in other Caſes two Meaſures and four-ninths; and again, in ſome Inſtances two Meaſures and a half.

The greater Differences of Bulk happened with different Parcels of permanent Vapour procured at different Times, and after various Degrees and Times of Expoſure to Heat, but ſmaller Differences appeared in different Trials with the ſame Parcel.

One Meaſure of nitrous Gas, was mixed with two Meaſures of common atmoſpheric Air; which Mixture immediately, upon Agitation, was attended with a turbid, Orange-coloured Appearance, Heat and Tranſparency; and a ſenſible Diminution of Bulk, ſucceeded in a few Seconds. Several Mixtures of this Kind were made, and after they had ſtood two or three Days, they meaſured from one Meaſure and ſix-ninths, to one Meaſure and eight-ninths.

A lighted Wax Taper was ſeveral Times introduced within a ſix Ounce Jar, filled with various

Parcels of this permanent Vapour ſeparated from Buxton-Water by boiling, by ſliding Part of the Mouth of this Veſſel over the Edge of a Tub quite full of Water, and returning it to its inverted Poſition over the Water the Moment the Candle was placed within the Bottle; the Flame was, upon the Introduction of the Taper therein, always inſtantly extinguiſhed.

The ſame Wax-Light introduced into the Jar juſt mentioned filled with common Air, and in the Manner above-related, burnt for the Space of ſeveral Seconds before it was extinguiſhed.

The ſame Species of *Quadrupeds* lived different Spaces of Time, and with various Degrees of Uneaſineſs, in a certain Bulk of this permanent Vapour of Buxton-Water, from the ſame Parcel. They always lived a *ſhorter Time* than in an equal Bulk of common Air, and always diminiſhed the Bulk of it by breathing and dying in it. For a middle-ſized vigorous Mouſe, introduced into a Receiver containing *three and a half Ounces Meaſure* of this permanent Vapour, ſtanding inverted in Water of 70° of Heat, lived without manifeſting Signs of Uneaſineſs thirty Minutes; it then began to ſhew Symptoms of Pain, its Eyes began to protrude, and it died in twenty Minutes further convulſed. In this Quantity of common Air, under the above Circumſtances, I apprehend this Species of Animal will live without Uneaſineſs forty Minutes, or upwards,

wards, in general. A Mouſe, introduced as above-mentioned, within a Receiver containing *two Ounce Meaſures* of this permanent Vapour of the tepid Water of Buxton, on its firſt Introduction appeared to be in Pain, as its Reſpiration was quick and ſhort, and its Eyes protruded; however, it lived thirteen Minutes, and then expired apparently in a paralytic State. Another Mouſe alſo introduced into two Ounce Meaſures of this permanent Vapour, as above-mentioned, died, after living only ſeven Minutes, and during this Time in Pain.

A Mouſe will commonly live about twenty Minutes with tolerable Eaſe, in two Ounces and a half Meaſure of common Air of a temperate Heat, and thirty or thirty-five Minutes before it dies.

This Experiment furniſhed a deciſive Proof, that a great Part of the permanent Vapour detached by expoſing Buxton-Water to Heat was *Air*; for this permanent Vapour only *combines* with nitrous Gas, and produces a conſiderable Diminution of the joint Bulk of theſe two Vapours mixt together, accompanied with a turbid Appearance and Heat during the Act of Combination: And in this permanent Vapour only, can Animals *breathe*, and by Reſpiration diminiſh its Bulk. But only a Part of the permanent Vapour ſeparated from Buxton-Water by Heat is Air; becauſe the Diminution of Bulk, on Mixture with nitrous Gas was always *much leſs*, ſometimes very conſiderably leſs, than with an equal Bulk of common Air, and becauſe it ſupported animal Life a *ſhorter Time* than an equal Bulk of common Air. This permanent Vapour of Buxton-Water *extinguiſhed Flame*; and as its Effects upon nitrous Gas and animal Life demonſtrate a Part of it to be Air, and as Air mixt with only a ſmall Portion of any other Species of permanent Vapour is unfit for ſupporting Flame, its Effects upon the lighted Wax Taper prove it to be a *Mixture of Air and ſome other Vapour.* The Air in which a Candle has burnt out, will ſupport Reſpiration nearly as long, and will diminiſh nearly as much with nitrous Gas, as Air of the ſame Parcel before the Extinction of Flame therein.

The various Degrees of Diminution with different Parcels of this permanent Vapour of Buxton-Water and nitrous Gas ſhew, that the *Proportion of Air* to the other Vapour or Vapours is *various*; which Variety will be accounted for hereafter.

Exper. XX. In order to judge better concerning the Effects of Buxton-Water, and to inveſtigate further the Properties of the permanent Vapour procured by the two laſt Experiments, I ſubjected *Matlock tepid petrifying Water*, and alſo ſeveral *Spring-Waters* near Doncaſter (that were hard Waters, and roſe out of a Bed of Gravel, and did not fur Veſſels conſiderably on boiling

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like Waters flowing from Lime-Stone Strata), to Heat in the Tin-Pan above-mentioned.

Theſe Spring-Waters, and the Matlock tepid petrifying Water detached *Vapour* with much the ſame Appearances as Buxton-Water in Experiment XVIII.

The Tin-Panful of Matlock-Water afforded *three Ounces and a half* to *four Ounces* Meaſure of permanent Vapour, under ſimilar Circumſtances of Preſſure and Temperature, as thoſe in Experiment XVIII.: And the Water, after being thus deprived of its permanent Vapour, had its Tranſparency diſturbed, and ſeparated a larger Quantity of earthy Matter than Buxton-Water, by boiling, upon this Occaſion. Five Panfuls yielded twenty Ounces and two Drachms Meaſure of this permanent Vapour, in November 1781, at the Spring-Head.

Each Tin-Panful of the Doncaſter Spring-Waters ſeparated, in general, not more than *three Ounces and a half Meaſure* of permanent Vapour, under nearly equal Preſſures and Heat of the Atmoſphere as thoſe to which Matlock and Buxton-Water were expoſed, as above related. The permanent Vapour of theſe Spring-Waters near Doncaſter, was ſeparated at different Times in the Months of November and December, 1781; and leſs Earth was found adhering to the Veſſels after boiling them, than after boiling thoſe of Buxton and Matlock.

The above permanent Vapours from Matlock-Water, and the common Springs near Doncaſter, had the ſame general Properties as thoſe related of the permanent Vapour of Buxton-Water, p. 232, 233, 234; to which we add, that theſe permanent Vapours were not diminiſhed by Expoſure to a Quantity of cauſtic Ley, and therefore we make the ſame Inference as that in p. 235.

We likewiſe obſerve, that the *ſparkling* Appearance of the Bubbles, during their Separation from theſe Spring-Waters by Heat, is very different from the Appearance of the Particles of Gas during its Separation from Water, which are very dull, like Particles of Sand, and exceedingly ſmall, as deſcribed p. 166, 167.

Alſo as the Diminution of Bulk was rather greater by Mixture of theſe permanent Vapours with nitrous Gas, than by Mixture of common Air with this Subſtance (*d*); as Animals lived with Eaſe, and as long, or longer, on repeated Trials of theſe permanent Vapours, than in common atmoſpheric Air;

(*d*) The turbid and Orange-coloured Appearance is moſt diſtinctly obſerved, by mixing the nitrous Gas and Air together in greeniſh Phials. The turbid Appearance was greater, and Orange Colour deeper, and of longer Duration, on mixing nitrous Gas with the permanent Vapour procured from the Doncaſter Springs, than I obſerved with the Mixture of the permanent Vapour from Matlock, or Buxton-Water. Whether this Difference denotes greater Purity, or depends upon ſome other Circumſtances, remains yet to be determined.

and as a Wax-Light burnt as long or rather longer in Receivers of theſe permanent Vapours, than in the ſame Receivers of Air of the Atmoſphere, it was inferred, that *Matlock tepid petrifying Springs, and the Springs near Doncaſter, examined upon this Occaſion, yield, by Expoſure to Heat in the Manner related, permanent Vapour, which is Air* (*e*) *ra-*

(*e*) The Biſhop of Llandaff obſerved, that Well-Water, River, and Rain-Water, diſcharge Air in about 60° of Heat of Fahrenheit's Thermometer; but that Matlock-Water, which is 68° of the ſame Thermometer, excepting in very hot Weather, does not ſeparate its Air viſibly.

Abbé Nollet found, that Water, which had been purged of its Air by boiling, abſorbed $\frac{1}{30}$ of its Bulk.

Dr. Hales procured, by Diſtillation, from 54 cubic Inches of Water, one cubic Inch of Air.

Eller detached Air, which was $\frac{1}{50}$ of the Bulk of the Water from which it was procured.

Dr. Prieſtley procured $\frac{1}{4}$ Ounce Meaſure of Air from a Pint of Pump-Water.

Abbé Fontana ſays, Seine-Water, after being long boiled, in 40 Days abſorbed $\frac{1}{28}$ of its Bulk of Air.

The Quantity of Air, that Water can abſorb, depends upon the Purity of it and the Air employed, and upon the Weight and Temperature of the Atmoſphere.

Mr. De Luc ſomewhere obſerves, that Water retains Air not ſeparable by Heat, or by removing the Preſſure of the Atmoſphere; but by long Agitation *in vacuo*.

The Air of Springs, and of diſtilled Water, has been found frequently purer than atmoſpheric Air. In 40 Days, Fontana ſays, Water abſorbs $\frac{1}{28}$ of its Bulk of common Air, and in the ſame Time $\frac{1}{14}$ of its Bulk of dephlogiſticated Air.

ther more pure than the Air of the Atmoſphere; and *not like Buxton tepid Springs of two or more Species of permanent Vapour,* viz. *Air, and permanent Vapour not reſpirable; but which is not Gas, or permanent Vapour that has any Smell, as hepatic Gas:* and which is probably that Vapour ſpoken of p. 152, 153, concerning which we ſhall make a particular Enquiry hereafter.

Buxton-Water, p. 175, Experiment II. formed with Lime-Water a milky Mixture, and on ſtanding depoſited a white Sediment; as did Matlock petrifying tepid Water, and the Springs near Doncaſter; from which Waters permanent Vapour, found to be chiefly or entirely Air, was detached by Expoſure to Heat, p. 238, 242. The Appearances in Exper. II. being nearly the ſame that ariſe on adding Lime-Water to diſtilled Water impregnated with Gas, are accounted for by ſuppoſing theſe Spring-Waters contain Gas, which combines with the Quicklime diſſolved in Water, and forms a compound, calcareous Earth, that is firſt ſuſpended throughout, and then precipitated in the Form of Sediment from the Water; becauſe Quicklime and Gas have a ſtronger Attraction for each other, than for Water with which the former makes Lime-Water, and with which the latter forms acidulous Water. But Water naturally or artificially impregnated with Gas, when expoſed to even leſs Degrees of Heat than thoſe employed p. 232, 240, is generally deprived of this Vapour (*f*). There-ſore it is inferred, that the Gas in Buxton, Matlock, and the common Springs examined, is either ſo combined with the Water (in a Manner different from

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(*f*) Dr. *Hales*, by Means of Heat, expelled both Gas and Air from Fountain-Waters; although he does not appear to have underſtood the Diſtinctions between theſe two Vapours. He ſays, "From two Quarts of Bath-Water Air, the Size of half a Pea only, was ſeparated." The ſame Event would have happened with Buxton-Water, and the common Spring-Waters I examined; becauſe they do not, by Heat, ſeparate Gas, but Air and permanent Vapour that is unfit for Reſpiration. "Neither will all the latent Air which is, by Heat, raiſed out of ſeveral Waters be reſorbed again, or loſe its Elaſticity till after ſeveral Weeks; as was the Caſe with the Airs from the Ebſham and Acton-Waters. But as to Pyrmont, Spaw, and Tunbridge-Waters, whence greater Plenty of this elaſtic Matter is raiſed by Heat, it does not continue ſo permanently elaſtic." The elaſtic Matter ſpoke of and reſorbed ſo readily is Gas, but that which is ſaid to be more permanently elaſtic was, probably, Air, or phlogiſticated Air.

Dr. *Prieſtley* ſays, "The Heat of boiling Water will expel all the fixed Air, if a Phial containing the impregnated Water be held in it; but it will often require about half an Hour to do it compleatly." Exper. and Obſerv. Vol. I. p. 31, 32.

Mr. *Cavallo*, ſee his Treatiſe on the Nature and Properties of Air and other permanently elaſtic Fluids, ſays, "Spring-Water retains fixed Air more obſtinately than Water artificially impregnated with it, which is owing to ſome earthy, or metallic Particles; for Water impregnated with fixed Air will eſcape in a few Hours, but this is not the Caſe with common Water naturally impregnated with fixed Air."

that in artificial and many natural Combinations) as not to be detached by Heat, or with ſome Subſtance contained in the Water, forming there-with a Compound incapable of Decompoſition by the Heat of boiling Water.

In proſecuting then the Inveſtigation of the permanent Vapours of Buxton-Water, the next Subjects of Enquiry that occurred were, to find the *Quantity of Gas* that was probably contained therein; and *the Kind of Subſtance with which it was combined*, together with its Mode of Combination.

Previouſly to entering upon theſe Enquiries, I thought it would be more ſatisfactory to manifeſt by actual Experiment, that the Sediment of precipitated Matter, formed by adding Lime-Water to the above Spring-Waters, was a Compound of Gas and Quicklime.

Exper. XXI. I took four wide Glaſs-Veſſels, called Sugar-Glaſſes, into one of which I poured two Quarts of *Buxton-Water*; into another, the ſame Quantity of *Matlock-Water*; into the third, the like Bulk of *a common Spring-Water*; and into the fourth, two Pints of *diſtilled Water ſaturated with Gas*. To each of theſe Veſſels were added three-fourths of a Pint of *Lime-Water*. A *milky Appearance* enſued immediately in the above three Spring-Waters, followed by the Formation of *Clouds* ſuſpended in various Parts, and after ſtanding twenty-four Hours, the Depoſition of a *white, looſe, and woolly Sediment* took Place in a clear colourleſs Fluid, nearly alike in all the three Glaſſes containing theſe Fluids. *No curdy Appearance* or *Clouds* happened in the diſtilled Water impregnated with Gas; but a *Sediment* gradually ſubſided to the Bottom, which was cloſe, even, and adhered firmly to the Bottom of the Veſſel. The Water was decanted from each of theſe Sediments, ſo as to leave behind about one Ounce of turbid white Fluid, that had neither Taſte nor Smell.

Concentrated *muriatic Acid* was poured Drop by Drop upon this Sediment. It excited an Efferveſcence, during which a Vapour was detached that was Gas; for it was readily ſoluble in diſtilled Water, to which it imparted an acidulous Taſte, it precipitated Lime from Lime-Water, and it was ſpeedily united with cauſtic Alkali. The muriatic Acid united with theſe Sediments formed Compounds of a bitter Taſte, like muriatic Selenites. *Vitriolic Acid* added to theſe Compounds of muriatic Acid and Sediment, produced a turbid white Mixture, which had the Smell of muriatic Acid.

The foregoing Experiment, perhaps, determined, in a ſufficiently ſatisfactory Manner, that the *Sediment*, formed after adding Lime-Water to Buxton, Matlock, and common Spring-Water, is *a Compound ariſing from the Union of the Gas of theſe Springs with the Quicklime diſſolved in Water.* The Precipitation formed by adding Lime-Water

ter to Gas and diſtilled Water was attended with a different Appearance from that which happened with Spring-Waters; which is a Particular worthy of Notice, and may be explained by the ſubſequent Experiments.

Article of Enquiry. The *Quantity of Gas* in the three above-mentioned Spring-Waters, it was conceived, might be determined by aſcertaining the exact Quantity of Lime-Water that ſaturates the Gas in each of the Springs, provided the Quantity of Gas that will ſaturate a given Bulk of Lime-Water be known. Or after preciſely ſaturating the Gas in theſe Waters with Lime-Water, and collecting the Sediment by aſcertaining the *Weight* of the Compound of Gas and Quicklime in each Water; and then, by decompoſing this Compound, we learn the Quantity of Gas it contains, which is the Quantity contained in a given Portion of Water. And the Quantity of Lime-Water the Gas thus extricated will ſaturate, we ſhould expect to be equal to that added to ſaturate the Gas in the Spring-Water.

Exper. XXII. The Reſult of a great Number of Trials made with Buxton-Water *taken freſh from the Spring* in the Winter and Summer Seaſon of the Year 1782; and with this Water *after remaining in Bottles* ſome Time; alſo with this Water *after being expoſed to the open Air*; mixed with Lime-Water ſoon after, and alſo ſome Time after making; with different Sorts of Quicklime uſed ſhortly after the calcareous Earth, from which it was produced, was decompoſed by Heat, diſſolved in hot and cold, hard and ſoft Spring-Waters, inſtructed me, 1. That Mixtures compoſed of *three Meaſures*, or a ſmaller Quantity of this Spring-Water, and *one* Meaſure of Lime-Water, after ſtanding a ſufficient Time in cloſe Veſſels for the Sediment to ſubſide, and pouring off the Water from the Sediment, had its Tranſparency diſturbed, or became pearly-coloured or milky, on the Addition of Gas. On the further Addition of Lime-Water it remained clear, but a Cruſt formed on the Surface of this Mixture by ſtanding. *Syrup of Violets*, of various Parcels, changed either a deep Graſs-green or yellowiſh Green, in falling through this Mixture, into which it was poured, or certainly was a deeper Green than before. Upon Agitation, this Mixture was either a deep Graſs or Yellow-green. Therefore it was concluded, that *one* Meaſure of Lime-Water was more than ſufficient to ſaturate the Gas contained in *three* Meaſures of Buxton-Water.

II. Mixtures compoſed of *four Meaſures* of Buxton-Water and *one* Meaſure of Lime-Water, under the Circumſtances above related, very generally, but not always, made a ſecond Precipitation, on the Addition of Lime-Water;—was always perfectly tranſparent after mixing it with a Portion of Gas;—formed, very generally, a more blue-coloured Mixture with Syrup of Violets, than the ſame Syrup and Buxton-Water, but, ſometimes, was greeniſh like Buxton-Water and this Syrup;—therefore, the general Concluſion made was, that the Gas contained in *four* Meaſures of Buxton-Water, is not ſaturated by *one* Meaſure of Lime-Water.

III. Mixtures compoſed of *ſeven* Meaſures of Buxton-Water and *two* Meaſures of Lime-Water, after depoſiting Sediment, in no Inſtance either formed a turbid Mixture on the Addition of Lime-Water, or of Gas; and the Colour of Syrup of Violets, as it lay at the Bottom of a Glaſs of this Mixture, was of a yellowiſh Hue; but when ſtirred and mixed with it, had rather a deeper caſt of Green, than this Syrup mixed with Buxton-Water. This Mixture, after being ſeparated from the Sediment, and ſtanding expoſed in open Veſſels to the Atmoſphere, had either a *Ring of white earthy Matter* formed round the Sides of the Glaſs in Contact with the Surface of the Fluid, or earthy Particles floated upon its Surface; and the ſame Appearance was obſerved with *fifteen* Meaſures of Buxton-Water and *four* Meaſures of Lime-Water; but, with a greater Proportion of this Spring-Water, as with *four* Meaſures of Buxton-Water and *one* Meaſure of Lime-Water, the Mixture poured off from the Sediment, was rarely even of a greeniſh Hue with Syrup of Violets, and had no Depoſition of earthy Matter upon the Sides of the Veſſel containing it, or upon the Surface of the Fluid. And with a ſmaller Quantity than *ſeven* Meaſures of Buxton-Water to one Meaſure of Lime-Water, the Fluid upon the Sediment, formed by this Mixture, uniformly produced a muddy Appearance, on the Addition of Gas; and was of a yellowiſh green, or green when mixed with Syrup of Violets.

Two Measures

From the Reſult here related it may be deduced, that *the moſt exact Proportion of Lime-Water that ſaturates the Gas in a certain Portion of Buxton-Water*, is *two Meaſures or Parts of Lime-Water to ſeven Meaſures or Parts of this tepid Spring.*

By the ſame Means employed to diſcover the exact Quantity of Lime-Water that would ſaturate the Gas in a certain Quantity of Buxton-Water, it was found, that *thirteen to fourteen Meaſures of Matlock-Water contain a Quantity of Gas which is ſaturated by one Meaſure of Lime-Water; and that two Meaſures of a Fountain-Water near Doncaſter, contained a Quantity of Gas that was not ſaturated by leſs than one Meaſure, or half of its Bulk of Lime-Water.*

Four Measures

Theſe two laſt Spring-Waters were examined under the ſame Circumſtances as the Buxton-Water.

Several other *common cold Springs* and *hard Waters* were examined, and found to contain Gas which was ſaturated by *two* Meaſures of Lime-

Water added to from *five* to *ſeven* Meaſures of Spring-Water; and the *Gas* contained in from *three* to *four* Meaſures of ſeveral *cold petrifying Springs*, was ſaturated by *one* Meaſure of Lime-Water.

Although the Quantity of Lime-Water that is neceſſary to ſaturate the Gas in a certain Quantity of Spring-Water, be not apparently varied by previous Expoſure of the Spring-Water to the Air, by keeping in cloſe Veſſels, and by the Seaſons or Times at which it is collected, excepting, perhaps, cold Springs, which are increaſed by Rain, and diminiſhed by Drought; yet there ſometimes appeared a Difference of about half a Meaſure in the Quantity of Spring-Waters containing Gas, required to ſaturate the Quicklime diſſolved in one Meaſure of Lime-Water; which Difference of Quantity, I was inclined to aſcribe to the Difference that may naturally be expected in the State of the Solution of Quicklime employed to combine with the Gas of theſe Springs; becauſe, when I had the Opportunity of examining ſeveral or all of the Springs above-mentioned at the ſame Time, with the ſame Parcel of Lime-Water, the ſame Difference of Quantity of Spring-Water extended in Proportion to all of them. Lime-Water may, among other Differences, contain a greater Portion of Lime in a State of Solution in a certain Quantity of Water at one Time than at another, owing to the Difference of the

Quicklime diſolved, the Water diſſolving it, Heat, Agitation, &c. to which the Quicklime was expoſed during Solution, accidental Precipitation of Quicklime after Solution by combining with the Gas of the Atmoſphere &c.; and, conſidering the Variety liable to happen in the Condition of the Lime-Water, it would not be ſurprizing if the Quantity of Solution of Quicklime required to ſaturate the Gas in a certain Quantity of Spring-Water, ſhould be various; although the Quantities and Qualities of the Gas to be ſaturated be uniformly the ſame.

Moreover, it muſt be remembered, that the Proportion found, which moſt exactly ſaturates the Gas in the Spring-Waters inveſtigated, was the Reſult of the Examinations of Mixtures of Lime-Water and Spring-Waters, that had not been left to ſtand more than five or ſix Days; for upon ſome, if not all Occaſions it happens, that a Mixture, which a few Days after being made, does not to the Teſt of Lime-Water manifeſt any Portion of Gas contained therein, on the contrary, even ſhews by the Addition of Lime-Water or Syrup of Violets, a ſuperabundant Portion of Lime-Water, after ſtanding two Months or longer, appears to contain Gas not ſaturated; becauſe it turns milky on the Addition of Lime-Water, and precipitates a freſh Portion of Sediment compoſed of Gas and Quicklime.

It appears upon eſtimating the Quantity of Gas in Spring-Water, by the Quantity of Lime-Water neceſſary to ſaturate it in a determinate Quantity of Water, that Buxton-Water contains nearly half the Quantity only of this permanent Vapour which is contained in ordinary Springs; and that Matlock-Water and petrifying Springs contain rather more Gas than Buxton-Water. How greatly, then, have Phyſicians erred in aſcribing the peculiar Efficacy of Buxton and Matlock-Waters to the Gas they contain! Further; that Principle muſt be exceedingly erroneous, which explains the petrifying or incruſtating Property of Springs to the Solution of calcareous Earth in Water by Gas; in Conſequence of the Eſcape of which, Earth is ſaid to be depoſited upon Bodies immerſed in ſuch Springs, and the Channels on the Surface of the Earth in which they flow, is incruſtated by the Depoſition of this Earth.

From the above Reſult the Queſtion ariſes, whether the moſt uſual or mean Quantity of Gas in Springs, is not that which is ſaturated by one-third of its Bulk of Lime-Water?

As the Attempt to eſtimate the Quantity of Gas in a Spring-Water, by the Quantity of Lime-Water required to ſaturate this Vapour in a given Portion of Spring-Water, has never yet, as far as I know, been made; and as that Mode of Eſtimation may furniſh an eaſier Method of aſcertaining this Point than the Application of Heat and Inſtruments, and may ſupply us with a Method in thoſe Caſes in which Gas cannot be detached by Heat; with the View of aſſiſting thoſe who wiſh to proſecute this Subject, I ſhall relate

Some Obſervations and Remarks on the Teſts employed to judge of the Saturation of Gas in Water with Quicklime diſſolved in Water.

In order to determine whether the Mixture of Spring-Water and Solutions of Quicklime contained ſuperabundant Lime-Water, a pretty large Quantity of it at a Time, as a Pint Jar full, was ſubjected to the Teſt of Gas.

After a great Number of Experiments, made with all the Exactitude that appeared poſſible, I muſt confeſs, that the Teſts employed are not ſufficiently delicate for ſhewing, either a ſmall Quantity of ſuperabundant Lime-Water, or a ſmall Portion of Gas which remains unſaturated, in Mixtures of Lime-Water and a Spring-Water containing Gas. Therefore, the Quantity of Lime-Water here ſtated as the Proportion that juſt ſaturates the Gas in the Spring-Waters examined, is only to be underſtood as the neareſt Approximation to the Truth, upon this Occaſion, that can at preſent be obtained. For, I have found, that diſtilled or Snow-Water, combined with a ſmall Quantity of Gas, (which diſtilled, or Snow-Water, before Gas was added, was found to make a perfectly tranſparent Mixture with

Lime-Water) will not have its Tranſparency apparently diſturbed on the Addition of Lime-Water, or form any Sediment, or Ring, on ſtanding: And, diſtilled Water, which forms a blue Mixture with Syrup of Violets, may have a ſmall Portion of Lime-Water added, and after ſuch Addition, will not have its Tranſparency diſturbed by the Addition of Gas or leave a Ring upon ſtanding, nor change Syrup of Violets of a greeniſh Hue. Alſo, the clear Fluid, poured off from the Sediment, formed by Mixture of Lime-Water and Gas, although it neither diſcovers ſuperabundant Lime-Water to the Teſt of Gas, nor Syrup of Violets, yet, by ſtanding expoſed to the Atmoſphere, it generally either precipitates earthy Matter upon its Surface, or a Ring of white earthy Matter collects round the Glaſs, which ſeems to ariſe from a Portion of Quicklime not ſaturated, (which is in too ſmall a Proportion to be detected by Gas, or Syrup of Violets) abſorbing Gas from the Atmoſphere; and being in too ſmall a Quantity, and divided into too minute Particles, to form Sediment, appears upon the Surface of the Water.

The Syrup of Violets was a more uniform and inſtructing Teſt of the Quantity of Lime-Water required to ſaturate the Gas of a certain Bulk of Water than, conſidering the delicate Nature of the Colour of the blue Juice of Violet Flowers, and the various Approaches it is liable to make towards a State of Acidity by keeping, I expected. I obſerved many Appearances which aſſiſted me much after I underſtood their Connection with the Gas or Quicklime diſſolved in Water, but I ſhall avoid relating particularly the various Phenomena upon Mixture of Spring-Water and Water containing Gas or Quicklime with this Subſtance, on Account of their increaſing too conſiderably the Bulk of this Work. I ſhall, therefore, mention only a few of the Appearances on mixing Syrup of Violets with Spring-Water, or Mixture of Spring-Water and Lime-Water.

I muſt firſt obſerve, that when I employed Syrup of Violets to judge whether the Gas in Spring-Water was ſaturated by Lime-Water, a Compariſon was made at the ſame Time between this Mixture, the Spring-Water alone or without Lime-Water, and between diſtilled Water mixed with the ſame Syrup; and that the Syrup was poured upon four Times its Quantity of Water.

1. If a Mixture, compoſed of Spring-Water and ſuch a Quantity of Lime-Water as was ſuppoſed nearly to ſaturate the Gas in the former, after depoſiting Sediment, was *yellowiſh Green*, the Spring-Water was *blue* or bluiſh Green, and diſtilled Water was *blue* when mixt with this Syrup, the Mixture contained more Quicklime than was neceſſary to ſaturate the Gas; for it became milky on the Addition of Gas, and even

taſted of Lime-Water. Such a Mixture alſo with this Syrup, by ſtanding twenty-four Hours, generally changed to a *brown Colour* or yellowiſh brown, while the Spring-Water and this Syrup remained *blue*, and the diſtilled Water and this Syrup was changed to an *almoſt colourleſs Fluid*.

2. If the clear Fluid from the Mixture of Lime-Water and Spring-Water imparted a *yellowiſh Colour* to the Syrup as it paſſed through the Water, and as it lay at the Bottom of this Fluid where it touched the Water, and on Agitation was *Green* or *Graſs-Green*; and the Spring-Water alone formed a *blue Mixture*, or a Mixture of a greeniſh Blue, and the diſtilled Water with this Syrup was a *paliſh Blue*; in this Caſe, the Spring-Water contained more Lime-Water than was neceſſary to ſaturate its Gas, but the Superabundance of Lime-Water was leſs than in the former Caſe: For, although it had its Tranſparency diſturbed by the Addition of Gas, and a ſlight Sediment was thereby formed on ſtanding, yet it ſcarcely had a Taſte of Lime-Water. This Mixture and Syrup generally became browniſh or colourleſs in about twenty-four Hours.

3. If the clear Water poured off from the Sediment after mixing Spring-Water and Lime-Water together was *green* when agitated with Syrup of Violets, the Spring-Water was *bluiſh green* or *blue*, and the diſtilled Water was *blue* with the ſame Syrup; as in this Caſe, ſometimes, there

was a pearly Colour on mixing this decanted Fluid with Gas, after which on ſtanding there was, now and then, a ſmall Quantity of Sediment, at other Times no Sediment, but a white earthy Ring round the Sides of the Glaſs in Contact with the Surface of Fluid, and again ſometimes neither Ring nor Sediment, and never in this Caſe any Milkineſs or Diſturbance in Tranſparency with Lime-Water, I was aſſured there was a complete Saturation of the Gas in the Water: But, it was uncertain whether there was not more Lime-Water than neceſſary to ſaturate the Gas, although certain that the ſuperfluous Lime-Water was in exceedingly ſmall Quantity.

4. After pouring off the clear Fluid from a Mixture with a ſmaller Proportion of Lime-Water to the Spring-Water, than any of the preceding Mixtures contained, it was found to make a *greeniſh*, or *bluiſh green Colour* with Syrup of Violets exactly like, or rather greener than, the Spring-Water and this Syrup; and mixed with Gas, and alſo with Lime-Water, neither had its Tranſparency diſturbed immediately, or on ſtanding depoſited a Sediment. Excepting very rarely, this Mixture which made a pale Blue or bluiſh Green with this Syrup, never depoſited the leaſt Sediment after the Addition of Lime-Water. Therefore this Mixture was conſidered as the neareſt Apprcach to the exact Point of Saturation that could be diſcovered.

5. I have ſometimes obſerved, that a Mixture of Spring-Water, and a ſtill ſmaller Proportion of Lime-Water than in the laſt Caſe, poured off clear from the Sediment, with Syrup of Violets, communicated a Tinge of a *greeniſh Colour* as this Syrup lay at the Bottom of the Mixture; but when agitated, the Colour of the Fluid was a *greeniſh Blue*, or blue like the Spring-Water alone, and the diſtilled Water with this Syrup was *pale Blue*. In this Caſe, there was in general no Diſturbance in the Tranſparency of this Mixture on the Addition of Lime-Water, or Gas, or Sediment after the Mixture of theſe Subſtances on ſtanding; but, at other Times, there was a ſlight Diſturbance in the Tranſparency and a Sediment, after the Addition of Lime-Water. The Colour of the Syrup and this Mixture diſappeared ſooner than the Colour with the Spring-Water and this Syrup.

This Proportion of Lime-Water, either nearly or compleatly ſaturated all the Gas in the Spring-Water; it certainly was not more than ſufficient to ſaturate it.

6. The Fluid poured off from a Mixture of Spring-Water and a ſmaller Proportion of Lime-Water than in the laſt Caſe, after depoſiting Sediment, with Syrup of Violets produced a *pale blue Colour*, nearly as pale as this Syrup with diſtilled Water; while the ſame Syrup and the Spring-Water, produced a greeniſh or greeniſh blue Colour: And there was always, or at leaſt, in

general, a ſecond Precipitation and ſmall Quantity of Sediment depoſited by the Addition of a freſh Portion of Lime-Water, and no Diſturbance in the Clearneſs after the Mixture of Gas with this decanted Fluid. The Syrup and this Mixture, as well as the Syrup and diſtilled Water, generally ſoon became nearly colourleſs; but this Syrup and this Spring-Water was ſtill a greeniſh Blue, or Blue after 12 or 24 Hours.

It was eſtimated that, upon this Occaſion, the Water was deprived of perhaps three-fourths of its Quantity of Gas. It appeared, that this Diminution of the Quantity of Gas and total Privation of this Subſtance, had the above Effect; ſo that it ſeems, as if Water partially or wholly deprived of Gas by Lime-Water, had its Power of producing a greeniſh Colour with Syrup of Violets deſtroyed, and like diſtilled Water, produced therewith a pale blue Colour.

7. Spring-Water that produced only a bluiſh Colour, or greeniſh Hue, with Syrup of Violets, after boiling, formed a Mixture that was of a green or greeniſh Colour, as happened with Buxton and Matlock-Waters. This is occaſioned, moſt probably, by the Water after boiling containing a greater Proportion, or being a more concentrated Solution of calcareous Earth, that like all other earthy Salts, changes Violets of a greeniſh or green Colour; for it did not appear

to contain a leſs Quantity of Gas than before boiling.

I am inclined to think, the Syrup of Violets is a more nice Criterion than Gas or Lime-Water, of the exact Point of Saturation of the Gas in Spring-Water by Lime-Water; provided the Mixture be made of this Syrup and the Spring-Water, and alſo of diſtilled Water, when the Mixture of Spring-Water and Lime-Water is examined; and not only the Colour be attended to, but alſo the Appearance or Diſappearance, or Changes of it on ſtanding.

Having aſcertained the Quantity of Lime-Water that will moſt exactly ſaturate the Gas in Buxton, Matlock, and in common Spring-Water, p. 250, *I next endeavoured to learn the Quantity of Gas that will ſaturate a certain Quantity of Lime-Water.—See Subject of Enquiry*, p. 247.

Exper. XXIII. According to the Inference from the laſt Experiment, p. 250, the Quantity of Gas required to ſaturate four Ounce Meaſures of Lime-Water, is the Quantity of Gas contained in fourteen Meaſures of Buxton-Water; the Quantity of Gas in thirteen to fourteen Meaſures of Matlock-Water; and the Quantity of Gas in double this Quantity of Lime-Water, of Spring-Waters near Doncaſter; and ſo on of the other Springs, mentioned p. 250, 251.

The Gas ſeparated from Chalk by vitriolic Acid, after paſſing through a wide Tube containing fixed vegetable Alkali, was combined in various Proportions, ſeveral Times, with the different Sorts of Lime-Water mentioned p. 247, 248; and the Reſult was, that the clear Fluid decanted, after uniting *four* Meaſures of this Gas, expoſed to the Heat of 58° to 64°, and under the mean Preſſure of the Atmoſphere, with *nine* Meaſures of Lime-Water, remained *perfectly tranſparent* after combining a freſh Portion of this Gas, and neither formed *a white earthy Ring* round the Sides of the Veſſel in Contact with the Surface of the Fluid, nor any *Sediment* on ſtanding; conſequently, that *four Meaſures of this Gas, of the Denſity above-mentioned, completely ſaturates nine Meaſures of Lime-Water.*

As the clear Fluid poured off, after combining *one* Meaſure of this Gas, under the above-mentioned Circumſtances of Preſſure and Heat, with *two* Meaſures of Lime-Water, on the Addition of more Lime-Water became ſomewhat pearly-coloured, and on ſtanding, depoſited a very ſmall Quantity of Sediment, or had a Ring of earthy Matter round the Sides of the Glaſs in Contact with the Surface of the Fluid; it may be inferred, that this Proportion of Lime-Water was ſuperſaturated by *one* Meaſure of Gas.

Moreover, as the clear Fluid decanted, after uniting *five* Meaſures of Lime-Water with *two* Meaſures

Meaſures of Gas, under the ſame Preſſure and of the Temperature above-mentioned, became leſs tranſparent, or rather pearly-coloured, on the Addition of a Portion of Gas, and was clear after adding Lime-Water, it may be concluded, that this Quantity of Lime-Water is not ſaturated by *two* Meaſures of Gas.

Hence it was found, that the neareſt Approach to the Point of Saturation of a given Bulk of Lime-Water by Gas, was *nine Meaſures of Lime-Water combined with four Meaſures of Gas*; heated to from 58° to 64°, and ſubjected to the mean Preſſure of the Atmoſphere; and, conſequently, as the Gas in *ſeven* Pints of Buxton-Water is ſaturated by *two* Pints of Lime-Water, *this Quantity of Buxton-Water contains* $\frac{4}{9}$, *or about* $\frac{28}{63}$ *of a Quart Meaſure of Gas*; *or, about one Ounce Meaſure of Gas is contained in eight Ounce Meaſures of this tepid Spring.*

On the ſame Grounds it was concluded, that *Matlock-Water contains the ſame Quantity, or rather more Gas than Buxton-Water*; *and, that two Pints of Spring-Water, near Doncaſter, contain about ſeven Ounce Meaſures of Gas.* Theſe Meaſures of Gas are ſuppoſed aſcertained, when ſubjected to the mean Preſſure of the Atmoſphere, and expoſed to a Temperature of 58° to 64°.

This Concluſion, reſpecting the Quantity of Gas in theſe Spring-Waters, is likewiſe founded on the Suppoſition, that the Gas is *in the ſame*

State naturally combined with theſe Waters, as that which is ſeparated by Art, in the Manner above-mentioned, from calcareous Earth; and, that this Vapour extricated from Chalk, &c. is uniformly in the ſame State as to Degree of *Concentration or Purity.*

If, upon a Repetition of this Experiment, the Reſult ſhould be different from that here related, which, from the Teſts employed, to judge of the Saturation of Lime-Water with Gas not being ſufficiently delicate, from the different Qualities of the Lime-Water, and the probable Difference in the State of the Gas, I apprehend, is very likely to be the Caſe: ſtill, the relative Quantities of the Gas here ſtated, in the Waters examined, may be accurate; and unleſs the Eſtimate be very erroneous indeed of the Quantity, the practical Concluſion will be the ſame as that we ſhould draw from this ſuppoſed Fact; namely, *that the tepid Waters of Buxton have no peculiar Efficacy dependent upon the Gas they contain, whether the Quantity of it be as above aſſigned, or twice, or three Times that Quantity.*

I proceeded in the next Place, to enable myſelf to judge more ſatisfactorily of the Quantity of the Gas in Buxton, Matlock, and the Spring-Waters near Doncaſter, *by combining the Gas contained therein, with Quicklime diſſolved in Water, and collecting this Compound agreeable to the Enquiry propoſed* p. 247.

Exper. XXIV. To the following Kinds and Quantities of freſh drawn Spring-Water, in large and glazed deep earthen Veſſels, were added the Quantities of Lime-Water below-mentioned.

Immediately upon pouring the *Lime-Water* upon the *Spring-Water* a *Milkineſs* enſued; in 25 or 30 Minutes, the Mixture was like *Maſſes of Curds ſuſpended in Abundance uniformly throughout a watery Fluid*; on ſtanding longer, *larger curdy Maſſes or Clouds* collected, ſome of which were ſeen floating upon the Surface of the Mixture; others were ſuſpended irregularly, in various Parts of a Fluid as tranſparent as the Spring-Water itſelf; and ſome were depoſited, in Form of a curdy white Sediment. To the ragged Edges of theſe curdy Maſſes, Bubbles of Vapour were ſeen adhering, by Means of which, they were partly, if not entirely, ſuſpended, and aſſumed the various Shapes of Clouds; for when, by a warm Expoſure, theſe Bubbles were made to detach themſelves from the precipitated curdy Maſſes, and riſe to the Surface of the Mixture, where they formed Cluſters or Rings of Beads of Vapour, they were obſerved to fall towards, or to the Bottom of the Veſſel. Sometimes in a warm Situation, the precipitated Matter was ſuſpended in the Form of Ropes hanging from the Surface of the Fluid, where they had theſe Bubbles adhering to their Terminations; and ſometimes, the

Sediment roſe from the Bottom of the Veſſel, in Strings or ropy Maſſes, to ſome Height in the Fluid, with Bubbles adhering to their Sides and Tops.

After ſtanding four, five, or ſix Days, the Whole of the *precipitated Matter* was *depoſited* at the Bottom of the Veſſel, forming a *light woolly Sediment.* The clear Fluid was then poured off, ſo as to leave behind a Pint or a Quart of Milk-like Fluid, that was put into ſmall Jars; and after it had ſtood ſome Days in covered Veſſels effectually excluded from the Atmoſphere, that the Sediment might be depoſited, the clear watery Fluid was decanted, and left a few Ounces of white, thick, and Cream-like Fluid, which was evaporated ſlowly to Dryneſs. This dried Sediment was *white, friable, light, perfectly ſmooth,* and *inſipid*; it weighed as follows.

	Dwt.	Gr.
The dried Sediment, procured by adding ſix Wine-Pints of Lime-Water to 21 Wine Pints of Buxton-Water, weighed — —	4	3½
——————— from ſeven Pints of Lime-Water and 24 ½ Wine-Pints of Buxton-Water —	4	6.

The Gas was *exactly ſaturated* in theſe two laſt Mixtures, there being three and a half Meaſures of the tepid Water of Buxton to one Meaſure of Lime-Water.

	Dwt.	Gr.
———— from ſeven Pints of Lime-Water and 21 Wine-Pints of Buxton-Water, weighed	4	3;
———— Ditto —	4	2.

In the two foregoing Inſtances, the Gas of the Buxton-Water was *not ſufficient to ſaturate* the Lime-Water added; but in the following ones, the Gas of this Water was *more than ſufficient* to ſaturate the Lime-Water added.

	Dwt.	Gr.
Twenty-eight Pints of Buxton-Water and ſeven Wine-Pints of Lime-Water yielded — —	4	14.
Twenty-four Wine-Pints of this Spring-Water and ſix Wine Pints of Lime-Water afforded —	4	0;
And 27½ Pints of this tepid Spring and five and a half Pints of Lime-Water, gave of Sediment —	5	8.
Ditto ſecond Trial afforded of Sediment — —	4	10.
Twenty-four Wine-Pints of a Pump-Water, that required 12 Wine-Pints of Lime-Water to ſaturate its Gas, depoſited of Sediment	6	10.
Ditto ſecond Trial —	6.	5.
Ditto third Trial —	6	10.
The ſame Quantity of this Pump-Water and ſix Wine-Pints of Lime-Water, yielded of Sediment	5	4.
Ditto ſecond Trial — —	5	12.

	Dwt.	Gr.
Twenty-eight Wine-Pints of Pump-Water and eight Pints of Lime-Water, rendered of Sediment	8	6.

Obſervations. 1. As the Precipitation made by Mixture of Spring-Water with Lime-Water, is the Gas of the Spring-Water combined with the Quicklime diſſolved in Water; when Lime-Water is added to any Fountain-Water *exactly to ſaturate this Gas* contained therein; the Sediment collected we conſider to be the Whole of this Gas in the Water combined with the Whole of the Quicklime; and which, for aught we know, ſhould always *be the ſame in Quantity in the ſame Water*; provided the Water, from which it is precipitated, require the ſame Quantity of Lime-Water to ſaturate the Gas: And in this Reſpect, the Reſult of the preceding Experiment does not appear to differ conſiderably, in general, from what might be expected from this Theory.

Moreover, the Quantity of Sediment ſhould be the ſame in *different Spring-Waters*, where the ſame Quantity of Lime-Water is ſaturated with Gas contained in them; which, upon Trial, is not the Fact; for the Sediment procured from the Gas of 21 Pints of Buxton-Water exactly ſaturated by ſix Pints of Lime-Water, was 4 Dwt. 3 Grs. and the Gas exactly ſaturated by 12 Pints of Lime-Water added to 24 Pints of Pump-Water, was 6 Dwt. 10 Grs. or by 6 Pints of Lime-Water added to 12 Pints of Pump-Water, was 3 Dwt. 5. Grs.

2. After aſcertaining the Weight of Sediment, procured by exactly ſaturating the Gas in a certain Quantity of Water, we ſhould expect, that the Weight of Sediment might readily be inferred, when a *ſmaller Quantity of Lime-Water is added to the Spring-Water than is ſufficient to ſaturate the Gas it contains.* For Inſtance, if only half the Quantity of Lime-Water be added, that is requiſite to ſaturate the Gas of a certain Quantity of Water, the Weight of Sediment ſhould be half of that Sediment produced by completely ſaturating the Gas, in this Quantity of Fountain-Water. But this does not appear to have been the Event of the Experiment, for the Sediment afforded by 24 Pints of Pump-Water, and 12 Pints of Lime-Water weighed 6 Dwt. 10 Grains; and that afforded by 24 Pints of the ſame Pump-Water and 6 Pints of Lime-Water weighed 5 Dwt. 4 Grains, inſtead of 3 Dwt. 5 Grains only, as might have been expected from this Theory. And,

3. If to a certain Quantity of Spring-Water, *a greater Quantity of Lime-Water be added, than is neceſſary to ſaturate the Gas diſſolved therein,* the Weight of Sediment ſhould be the ſame, according to the Principle of Reaſoning employed upon this Occaſion, as that when the Gas of the Water is preciſely ſaturated by Lime-Water; and the Event of two Trials demonſtrated this to be the Fact: For this Gas in 21 Pints of Buxton-Water,

was exactly ſaturated by ſix Pints of Lime-Water, and afforded the ſame, or nearly the ſame Weight of Sediment, as this Quantity of Buxton-Water, and ſeven Pints of Lime-Water; or, as with one Pint more Lime-Water than was neceſſary to combine with the whole of this permanent Vapour of this Quantity of Buxton-Water.

Therefore it does not appear, that we can eſtimate the Quantity of Gas in a certain Quantity of Water, by the Weight of the Sediment produced by the Combination of this Gas with Quicklime, or merely by the Quantity of Lime-Water required to ſaturate this Subſtance.

This Experiment, however, affords another Proof of the Error in the Opinion of Phyſicians in general, that Buxton-Water contains a greater Quantity of Gas than is uſually found in Spring-Waters.

We are unable to account for the Difference between the Fact upon Trial in this Experiment, and the Reſult to be expected according to Principle, by any Properties of Subſtances yet known. We may conjecture, that Gas combines with Quicklime and forms different Subſtances therewith; each of which are depoſited in Sediment from Mixtures of Lime-Water and Spring-Water. A certain Quantity of Gas may combine with Lime-Water added in Quantity ſufficient to ſaturate the whole of this Vapour in the Water to which it is added, and form a Subſtance different from that produced when added in Quantity not ſufficient for this Purpoſe; and therefore, in the latter Caſe, the Weight of the Sediment is greater than might be expected from the Weight of the Sediment when the Gas in the ſame Spring-Water is ſaturated. Perhaps, alſo the Compound of Gas and Quicklime forming the Sediment when this permanent Vapour of the Spring-Water is fully ſaturated by Lime-Water, is more ſoluble in Water, than the Sediment formed by adding Lime-Water in Quantity not ſufficient to combine with the whole of the Gas in Spring-Water; by which Means, the Weight of the Matter depoſited is greater in the latter Caſe than might be expected, from the Weight of the Sediment in the former.

A Decompoſition of theſe Sediments, and Meaſurement of the Gas ſeparated from them, might throw further Light on this Subject, and either verify, or ſhew the Falſehood of the above Conjectures. We ſhould expect the Gas detached from theſe Compounds, would ſaturate as much Lime-Water as that added to ſaturate the Gas in the Spring-Water and the Bulk of it to be four-ninths of a Pint Meaſure, ſee Page 263, for every Pint of Lime-Water ſaturated by the Gas of the Spring-Waters.

Suppoſing the Gas in the above Sediments to be in the ſame Quantity in all, and that Quantity to be three-eighths of their Weight, then the Weight of this Subſtance in the Sediments formed ed by preciſely ſaturating the Gas in 21 Pints of Buxton-Water will be about 36 Grains, p. 266. the Bulk of which, under a mean Preſſure, and ſubject to a temperate Heat, will be, perhaps, about one-third leſs than the Bulk of an equal Weight of Air, under the ſame Preſſure and of the ſame Heat, or about 24 Ounce Meaſures inſtead of 42 Ounce Meaſuers, according to a former Calculation, ſee p. 263; and the Quantity of Quicklime in ſix Pints of Lime-Water thus ſaturated, is 60 Grains, or 10 Grains of Quicklime in a Pint of Lime-Water is ſaturated by about ſix Grains, or about four Ounce Meaſures of Gas. And by the ſame Method of Deduction, 24 Wine Pints of Pump-Water, p. 263, contain about 72 Grains of Gas, or three Pints Meaſure of this Vapour, inſtead of 84 Ounce Meaſures, according to the Calculation, p. 263.

The following Experiment was made before that laſt related, but not being performed with the ſame Exactitude, the Inferences to be drawn from it are not to be conſidered as ſo well founded.

Exper. XXV. The Gas of the three following Spring-Waters, was combined with the Quicklime diſſolved in Lime-Water; and this Compound collected in Form of Sediment, with ſuch a Quantity of Water as to make it of the Conſiſtence of Cream.

This Sediment was put into a Retort that held about 12 Ounce Meaſures, and through a ſmall

Hole in the Shoulder of this Veſſel was poured gradually vitriolic Acid, till the Effervefcence excited by this Acid entirely ceaſed; immediately after pouring in the Acid, the Hole in the Shoulder of the Retort was ſtopped with the Finger, and the permanent Vapour ſeparated was received in a Jar filled with Water ſaturated with Gas, held inverted over the Mouth of the Retort in a large Baſon of Water ſaturated alſo with Gas; in which Jar the permanent Vapour was meaſured, after Expoſure to the mean Heat and Preſſure of the Atmoſphere.

1. The Sediment depoſited, after adding five Pints of Lime-Water to 20 Pints of Buxton-Water, afforded, on two Trials, about 28 Ounce Meaſures of permanent Vapour, which combined wholly (excepting a few Drachms of Air,) with Water, and formed acidulous Water; which Vapour formed calcareous Earth when joined with Quicklime, and mild Alkali when united with cauſtic Alkali, and which therefore was Gas.

2. The Sediment depoſited, after adding ſix Pints of Lime-Water to 20 Pints of Buxton-Water, ſeparated 28 Ounce Meaſures of Gas upon one Occaſion; and on two Repetitions, 26 Ounce Meaſures of this permanent Vapour each Time.

3. The Matter precipitated by mixing 12 Pints of Pump-Water with ſix Pints of Lime-Water, which preciſely ſaturated the Gas of this Water,

detached 19 Ounce Meaſures of Gas. The Sediment from 20 Pints of this Pump-Water and 10 Pints of Lime-Water, detached 28 Ounce Meaſures of Gas. And the Sediment from 72 Ounce Meaſures of this Pump-Water and 14 Ounces of Lime-Water, rendered ſix Ounce Meaſures of this permanent Vapour.

4. The Compound of Gas and Quicklime, formed by mixing 15 Pints of Matlock-Water with four Pints of Lime-Water, detached, by Computation, 12 Ounce Meaſures of Gas.

Gas from each of the above Sediments, was combined with the Quicklime in Lime-Water of the ſame Parcel as that employed to precipitate this permanent Vapour from the Spring-Waters; and it appeared, that it required nine to ten Meaſures of this Lime-Water to exactly ſaturate four Meaſures of this permanent Vapour, or about a Pint of Lime-Water was nearly ſaturated by ſix and a half to ſeven Ounce Meaſures of this Subſtance under the mean Preſſure, and expoſed to a temperate Heat of the Atmoſphere.

Obſervations. It was inferred, Page 263, that the Quicklime of a Pint of Lime-Water was ſaturated by ſeven Ounce Meaſures of Gas contained in Spring-Water, becauſe this Quantity of this Vapour, of a temperate Heat, ſaturated the Quicklime diſſolved in a Pint of Lime-Water.

It was eſtimated, Page 272, that 21 Pints of Buxton-Water contained 24 Ounce Meaſures of

Gas, when ſaturated by ſix Pints of Lime-Water; and that a Pint of Lime-Water, thus ſaturated with the Gas of Buxton-Water, yielded, according to this Method of Eſtimation, four Ounce Meaſures of this Vapour;—that 24 Pints of Pump-Water, which had its Gas ſaturated by 12 Pints of Lime-Water, rendered 48 Ounce Meaſures of this permanent Vapour, or each Pint of Lime-Water ſo ſaturated, contained, upon this Ground of Reaſoning, four Ounces Meaſure of this permanent Vapour; becauſe, 21 Pints of Buxton-Water contained about 36 Grains Weight of Gas; and 24 Pints of Pump-Water afforded 72 Grains Weight of this Subſtance; and it appeared, that no Eſtimate can be made from the *Weight* of the Sediment, when the Gas of the Spring-Water to which Lime-Water is added, is only *partially ſaturated* (p. 268—273).

The *Quality* of the Gas precipitated from the above Sediment was not different, in Degree of Concentration, or in Purity, from that employed to ſaturate the Quicklime in Lime-Water; becauſe it required the ſame, or nearly the ſame Quantity of the Gas of this Sediment, as of Gas of Chalk, to ſaturate a certain Quantity of Lime-Water.

As the Gas precipitated from the Spring-Waters, and the Lime ſeparated from the Lime-Water, which are contained in the Sediment, is the *Whole* of the Lime diſſolved in Lime-Water

added,

added, combined with the Gas of the Water, we ſhould expect that this Gas, when precipitated from the Sediment, would ſaturate the ſame Quantity of Lime-Water as that added to ſaturate the Gas in the Water; but as it was not in ſufficient Quantity for this Purpoſe when the Gas was completely ſaturated in the Spring-Water, a Part of the Compound of Quicklime and this permanent Vapour was wanting in the Sediment, and probably was diſſolved in the Water, as conjectured p. 271.

In the foregoing Experiment, the Quicklime diſſolved in each Pint of Lime-Water, ſaturated with the Gas contained in Buxton-Water, afforded, by Admeaſurement, from four Ounces and three Quarters to five Ounces and three Quarters Meaſure of this permanent Vapour; and the Quicklime diſſolved in each Pint of Lime-Water, ſaturated with the Gas of Pump-Water, yielded about three Ounce Meaſures of Gas, when this Subſtance in this Water was entirely or nearly ſaturated: but the Sediment formed by adding Lime-Water to combine with a Part of the Gas only of this Water, afforded after the Rate of ſeven Ounce Meaſures of Gas from each Pint of Lime-Water ſaturated. This Reſult renders the Conjecture (p. 270, 271) more probable.

The Sediment procured by combining Quicklime with *the Gas of Matlock-Water*, when this Water was nearly ſaturated, yielded about three

Ounce Meaſures of this permanent Vapour from the Quicklime diſſolved in each Pint of Lime-Water, and then ſaturated by the Gas of this Water.

It appears then, that the only Method by which we can aſcertain with any tolerable Exactitude, the Quantity of Gas in Spring-Water is, *to learn the Quantity of Lime-Water that will preciſely ſaturate this permanent Vapour in a certain Quantity of Water; and as the Gas in the Water is of the ſame Kind as that ſeparated by Art from calcareous Earths*, ſee p. 274, 275, *the Quantity of Gas required to ſaturate a Quantity of Lime-Water equal to that ſaturated by Gas in a certain Quantity of Spring-Water, is the Quantity of this permanent Vapour contained in that Quantity of Spring-Water.*

In this Way we aſcertained the Quantity of Gas in *Buxton*, *Matlock*, and *ſeveral common Spring-Waters*, p. 250, 251. 263, whence many practical Inferences in Phyſick, and the Principles upon which are explained ſome Phenomena in natural Hiſtory, will be found erroneous.

Having completed the Inveſtigation of the *Quantity of Gas* in Spring-Waters, propoſed p. 245, I proceeded to inform myſelf, *in what Manner*, and *with what Subſtance, the Gas ſhewn to be contained in them*, p. 246, *is combined*; and which apparently could not be ſeparated by the boiling Heat of Water, applied for ſeveral Hours, p. 231. 239. 242.

I made the three following Experiments, to determine deciſively, whether any Gas was ſeparated from Buxton-Water by the Heat of boiling Water.

Exper. XXVI. Various Quantities of *Lime-Water* were added to a certain Quantity of the *Buxton-Water that had been ſubjected to a conſiderable Degree of Heat and had ſeparated permanent Vapour* (ſee Exper. XVIII. p. 231); and to *Matlock tepid Water*, and *common Spring-Water*, which had been expoſed to Heat, and detached *Air*; (ſee Exper. XX. p. 239); with which they formed *turbid* Mixtures, with nearly the ſame Appearances as before being heated, excepting, that *no ſparkling and apparently aerial Bubbles* were ſeen, when in a warm Expoſure, as happened with Spring-Waters that had not been expoſed to Heat, as related Exper. XXIV. p. 265. Theſe turbid Appearances aroſe from the ſame Cauſe, viz. the Gas contained in theſe Waters; which permanent Vapour, required the ſame Quantity of Lime-Water to ſaturate it that it required to ſaturate this Vapour in unboiled Water.

As the Waters here examined, required as great a Quantity of Lime-Water to ſaturate the Gas contained in them after boiling as before Expoſure to Heat; and as it has been ſhewn, Exper. XVIII, XIX, *and* XX. *that the permanent Vapour ſeparated did not contain any Gas, this Experiment may be conſidered to be deciſive, that theſe Waters* *do not part with their permanent Vapour by a boiling Heat.*

Exper. XXVII. A large Quantity of *Lime-Water* was made of *Buxton-Water*, of *Matlock-Water*, and of the *cold Springs near Doncaſter*, immediately after taking them from the Spring, and preſerved in a cool Situation, in Veſſels cloſed from the Air till employed.

Several Tin-Pans full of Solutions of Quicklime in theſe Spring-Waters, were expoſed to Heat, in order to ſeparate *Air*, or any other permanent Vapour, in the Manner deſcribed p. 231, 232; by which Means, permanent Vapour was ſeparated with preciſely the ſame Appearances, as related during its Separation from Buxton-Water and other Springs, p. 232 to 235 and 240, and in the ſame Quantity, and of the ſame Quality, ſee p. 232 to 235, and 241.

The Gas in the three above-mentioned Spring-Waters, was in one Parcel of each, *preciſely ſaturated* with Lime-Water (p. 249, 250) made with the ſame Spring-Water to which it was added; in a ſecond Parcel, it was *more than ſaturated*; and in a third Parcel, it was *not ſaturated* by this Solution of Quicklime.

The clear Fluids were decanted from the Sediment depoſited in theſe Mixtures, and expoſed to Heat in the Tin-Pan juſt mentioned, uſed for collecting permanent Vapour: they all detached *the ſame Kind* and *Quantity* of permanent Vapours,

and

and with *the ſame Appearances*, as the Lime-Waters above-mentioned, made of theſe Waters.

This Experiment affords another Proof, that *Buxton, Matlock, and common Spring-Waters, by Means of a boiling Heat, in Exper.* XVIII. *and* XX. *did not ſeparate Gas; for in this Experiment, theſe Waters detached permanent Vapour, of the ſame Kind, and as copiouſly without as with their natural Portion of Gas.*

Moreover, the *ſparkling Appearance* taking Place upon heating Water deprived of Gas, as well as in Water in its natural State, is a convincing Argument, that this Phenomenon does not depend upon Gas. This Appearance of Air-Bubbles, has been frequently falſely aſcribed to Gas; but the Particles of this Vapour do not ſparkle, or are not ſo brilliant as Air, but dull, ſmall, and ſandy-like, as before obſerved, p. 241.

Exper. XXVIII. Two Quarts of *Buxton-Water* in a Retort, that was capable of holding three Quarts, were diſtilled with a gentle Heat into a Receiver containing one Quart of Lime-Water. The Receiver was luted *cloſely* to the Retort. As the Water evaporated, the Sides of the Retort appeared covered with a ſeemingly *earthy Matter*, in ſmall Quantity. The Lime-Water in the Receiver had a *thin Cruſt* formed upon its Surface, before any evaporated Water was condenſed, or any *Bubbles* had burſt upon the Surface of the Water in the Retort; and it was very little or not at all increaſed in Thickneſs, after the Condenſation began. In the Courſe of the Diſtillation, which was continued till about eight Ounces only remained in the Retort, the Water in the Receiver became rather *turbid*; which appeared to be occaſioned by the Cruſt formed upon the Surface of the Lime-Water, before, and in the Beginning of the Diſtillation, mixing with the Lime-Water and condenſed Water. By ſtanding, a ſmall Quantity of *white Sediment* was depoſited in the Receiver.

Rain-Water, that only contained an exceedingly ſmall Quantity of Gas, in the ſame Quantity, and in the ſame Manner as above-deſcribed, was diſtilled. *Exactly the ſame Appearances in the Receiver containing the Lime-Water took Place, but a ſmaller Quantity of earthy Matter was depoſited upon the Sides of the Retort.*

The eight Ounces of *Buxton-Water* remaining in the Retort was tolerably *clear*; and required *as much, or rather more Lime-Water* to ſaturate its Gas, than before a Quart of it was diminiſhed to this Quantity by Diſtillation. The *Rain-Water* remaining after the above Quantity was diſtilled after Mixture with Lime-Water, depoſited in the ſame Manner as before Expoſure to Heat, a very ſmall Quantity of *white Sediment*.

I have ſeveral Times diſtilled *Buxton*, *Matlock*, and the *Spring-Waters* near Doncaſter, but never found that theſe Waters diſtilled formed turbid

Mixtures with Lime-Water, or that they depoſited Sediment on ſtanding, as before Evaporation, after the Addition of Lime-Water; but they *ſparkled* on being heated, and appeared to be ſaturated with Air. They all incruſted the Retort with earthy Matter as the Water evaporated.

Obſervation. In this Experiment we ſhould expect to ſee the Lime-Water in the Retort become *milky* ſoon after the Evaporation, if the Waters ſeparated Gas by Heat; but it does not appear, that the Cruſt and ſubſequent turbid Appearance in this Experiment, were occaſioned by this Subſtance extricated from the Water in the Retort, but merely from Gas contained in the Air within the Veſſels in which the Experiment was performed; for the ſame Appearance occurred during the Diſtillation of Rain-Water, that was previouſly found to contain an exceedingly ſmall Portion of Gas, and which remained in the Water not evaporated in the ſame Quantity as before Expoſure to Heat.

Farther, conſidering the ready and copious Abſorption of Gas by Water, we ſhould naturally expect to find diſtilled Spring-Waters that contain it, ſuch as thoſe examined in this Experiment, to be impregnated with this permanent Vapour; but, I have never yet found diſtilled Water of the above Springs, or any other common Springs, to become turbid by adding Lime-Water, or to form a Sediment on ſtanding. Moſt probably, however, thoſe Fountain-Waters which ſeparate Gas by Heat as the *Acidulæ*, of which Number are *Pyrmont*, *Spaw*, *Driburg*, *Seltzer-Waters*, &c. when diſtilled, contain this permanent Vapour.

Rain-Water and *Lime-Water*, after being mixed together, either remain quite clear and do not depoſit any Sediment, or there is a very ſlight Diſturbance in the Tranſparency of this Mixture, and a very ſmall Quantity of Sediment on ſtanding. But, *Rain-Water* is the Water of *Springs*, *Rivers*, *Lakes*, and *Seas*, (almoſt all of which contain Gas to the Teſt of Lime-Water) evaporated by the Heat of the Surface of the Earth and the Atmoſphere, and, probably, contains neither Gas, nor any other extraneous Matter, any more than diſtilled Water; but, as it paſſes through a pretty large Tract of the Atmoſphere, in its Way to the Surface of the Earth, it is liable to combine or mix with various foſſil, animal, and vegetable Matters; among theſe, with Gas; and alſo to become ſaturated with Air.

This Experiment will ſerve to rectify the Error of a very prevailing Opinion, namely, that *a Spring-Water, which to the Teſt of Lime-Water appears to contain Gas, and which on boiling depoſits calcareous Earth, contains this Earth diſſolved by Means of Gas*; for this earthy Subſtance, I have ſhewn, is depoſited, during Evaporation; and at the ſame T me I have deciſively proved, that no

Gas is extricated. Hereafter will be ſtated the Arguments to render it probable, that Subſtances are never or rarely *ſuſpended* in Springs by Means of Gas, and never *diſſolved* therein by Means of this permanent Vapour.

This Experiment furniſhes *a third deciſive Proof, that Buxton-Water does not ſeparate Gas by Heat and Evaporation.*

As it is proved, that Buxton and other Spring-Waters contain Gas; that they do not ſeparate any Part of this Subſtance by Heat; and that, when reduced to one-fourth of their Bulk by Evaporation, they do not contain deciſively a larger Quantity of it than before Expoſure to Heat, and therefore a Portion of this permanent Vapour is wanting in Proportion to the Quantity of Water evaporated; the Queſtion occurred, in what Manner is this Gas diſpoſed of during Evaporation? I ſatisfied myſelf further of the Reality of this Fact, by evaporating ſeveral Times the above Spring-Waters to one-eighth, or even a leſs Quantity, and always found the remaining Waters to require the ſame, or nearly the ſame Quantity of Lime-Water to ſaturate their Gas, as before Evaporation. This Fact, at firſt, appeared to me inexplicable, and a Matter of Importance to be underſtood.

I had conjectured alſo, that the Gas in theſe Waters was combined with the ſimple Water ſo intimately by Nature, as not to be diſunited by the Heat of boiling Water; for the longer a Solution of Gas in diſtilled Water is *kept*, the more intimate the Union between theſe two Subſtances is; but, the Event of this Experiment, which ſhewed that Gas was contained in the ſame, or nearly in the ſame Quantity, in theſe Waters after evaporating any Portion of them, proved this Conjecture to be falſe.

After reflecting ſome Time on the above Phenomenon, an hypothetical Explanation of it occurred.

An Hypotheſis.

The Gas, of which theſe Spring-Waters were deprived in Proportion to the Evaporation, was neither contained in the Water evaporated, nor in the Water left unevaporated; but I obſerved, *calcareous Earth* to be depoſited as the Evaporation proceeded; ſo that the Water to be evaporated contained the ſame, or nearly the ſame Quantity of this earthy Salt, in a State of Solution. After contemplating the Properties of this Subſtance I conceived, that the Gas in theſe Waters was combined with Quicklime forming calcareous Earth, and not with ſimple Water, as happens when this Gas is diſſolved in diſtilled or elementary Water. I conſidered, that calcareous Earth was a Subſtance compoſed of Quick-lime and Gas, or perhaps, more properly, of Gas and the Compound of Quicklime and Gas. If Quicklime

lime be either a Species of cauſtic fixed Alkali (*g*), or has many Properties of that Subſtance, and Gas be an Acid, the Compound of theſe two Subſtances form a *neutral*, or more properly, an *earthy Salt*, called *calcareous Earth*; a Subſtance ſoluble in ſmall Proportion in Water, like another neutral Salt with Quicklime for its Baſis, vitriolic Selenites. Cauſtic fixed vegetable Alkali, cauſtic fixed foſſil Alkali, and volatile Alkali in a cauſtic State combine with Gas, and this Compound, mild Alkali, unites with Gas, and forms a different Subſtance, namely, *the Compound of mild Alkali and Gas*, which is ſeemingly a a neutral Salt (*h*). Mild Alkali, or Alkali in the State uſually produced by Art is cauſtic Alkali combined with a Proportion of Gas not ſufficient to neutralize it, or deſtroy any of its Properties, excepting its Cauſticity.

Quicklime, like other cauſtic Alkalies, unites with Gas and forms therewith a Compound; which Compound, it was conceived, combines with freſh Gas, and forms a different Subſtance, perhaps, calcareous Earth in the State in which it is found naturally

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(*g*) Dr. *Cullen*, as I before obſerved, formerly conſidered Quicklime as an alkaline Salt. See *Notes written by ſeveral Pupils at his chymical Lectures*.

(*h*) Vide the Appendix to Dr. Prieſtley's ſecond Vol. of Experiments and Obſervations on Air, in which are related Mr. *Bewley*'s Experiments.

Mr. *Bergman* has alſo ſhewn Gas to be an Acid. Vide Mr. *Cavallo*'s Work on Air, 4to.

naturally in the Bowels of the Earth, in Springs, and elſewhere.

If two Subſtances, one a Compound of the Compound of cauſtic Alkali and Gas united with Gas, the other cauſtic Alkali, be diſſolved in Water, and mixed together; the Gas combined with *the Compound of Gas and cauſtic Alkali* will be attracted by the cauſtic Alkali, and only one Kind of Subſtance, viz. the Compound of Gas and cauſtic Alkali will be found in the Water; excepting, perhaps, a Portion of ſuperabundant Compound of Gas and mild Alkali, or of cauſtic Alkali. In like manner, if to a Solution in Water, of Gas and the Compound of Gas and Quicklime, i. e. calcareous Earth, be added a Solution of Lime, this laſt Subſtance will decompoſe the other Compound by uniting with the Gas combined with the Compound of Quicklime and Gas; and thus there will be only one Kind of Subſtance in the Water, viz. Quicklime combined with Gas; excepting, perhaps, a ſmall Quantity of ſuperfluous Quicklime, or redundant Compound of Quicklime and Gas united with Gas.

This Hypotheſis is founded on a Fact in Chymiſtry, that different Subſtances may be formed of the ſame Elements, according to the Proportion of theſe Elements to each other. For Inſtance, Phlogiſton and vitriolic Acid form volatile vitriolic Acid; and volatile vitriolic Acid and Phlogiſton, compoſe Sulphur; Calx of

Quickſilver and muriatic Acid form corroſive Sublimate; and this Subſtance and muriatic Acid form Muria Mercurii; and corroſive Sublimate and Calx of Quickſilver make Calomel.

On this Hypotheſis we can explain, why Gas cannot be ſeparated by Heat equal to that of boiling Water, becauſe it is combined with Quicklime, or with *the Compound of Quicklime and Gas*, which cannot be decompounded by this Heat. And it is not found in greater Quantity in the Water remaining after evaporating a large Quantity of any given Portion from it, becauſe the calcareous Earth is precipitated as the Evaporation proceeds. Moreover, this Hypotheſis explains why the Quantity of Gas, procured by decompoſing the Sediment formed by uniting the Quicklime of Lime-Water with the Gas of Spring-Water, (p. 270, 271) is leſs when the Gas of a given Quantity of Water is ſaturated by Lime-Water, than when the Gas of the ſame Quantity of Spring-Water is only partially ſaturated by Lime-Water; by ſuppoſing, that *the Compound of Gas and Quicklime* is attracted ſtronger than calcareous Earth, *the Compound of Gas and Quicklime and Gas* by Water; and that upon the Addition of Lime to Solution of calcareous Earth in Water, *the Compound of Gas and Quicklime* thus formed is ſufficient to ſaturate the Water; therefore it precipitates calcareous Earth, which contains more Gas in a given Weight, than Sediment formed after adding Lime-Water to ſaturate the Gas, becauſe it is only *Quicklime combined with Gas*; whereas, calcareous Earth is *the Compound of Gas and Quicklime united with Gas.*

To verify, or prove the Falſehood of every Part of this Suppoſition, would require many Experiments. The following Experiment was made with the View of proving, whether this Conjecture be wholly, or in Part, true.

Exper. XXIX. I took a Florence Flaſk, that held about three Pints, and poured into it two Pints of diſtilled Snow-Water; a ſmall Quantity of which, was previouſly found to remain perfectly tranſparent, and without depoſiting Sediment on ſtanding, after Mixture with Lime-Water. Two Drachms of Chalk, finely powdered, were added to this Quantity of diſtilled Water. The Neck of the Flaſk was ſtopped with a ſoft Cork. This Mixture was kept in a gentle Sand-Heat for a Fortnight, during which Time it was frequently agitated, and when ſhook formed a Mixture like Milk. After this Time, it was decanted and filtered through Paper; by which Means a Fluid was obtained as clear as the diſtilled Water before Mixture with Chalk, but which had an *earthy Taſte.*

To about eight Ounces of this *filtered Water* were added four Ounces of *Lime-Water*, which immediately occaſioned a *pearly-coloured turbid Appearance*, and which on ſtanding produced a *white woolly Sediment.* From this woolly Sediment as much Water was poured off as poſſible, and to one Portion of it was added a ſmall Quantity of *vitriolic Acid*, with which it *efferveſced* and formed *vitriolic Selenites*; and, on the other Part was poured *muriatic Acid*, whereby *muriatic Selenites* was produced.

To ſmall Quantities of this filtered Fluid were added *ſaturated Solution of Lead in nitrous Acid*, *ſaturated Solution of Silver in nitrous Acid*, and *Saccharum Saturni*; with all of which either immediately, or on ſtanding, the filtered Water became *leſs tranſparent* or *muddy*, and after ſtanding *depoſited Sediment*, while the ſame Subſtances with *diſtilled Water* produced either merely a very ſlight Diſturbance in the Tranſparency of the diſtilled Water by ſtanding, or much leſs Sediment than with this filtered Solution.

A Pint of this filtered Fluid was *boiled* in a Pint and a half Florence Flaſk. It ſeparated Bubbles, apparently of *Air*, during the firſt ten Minutes of boiling; but afterwards only diſcharged thoſe large *non-permanent* Bubbles of Vapour peculiar to boiling Water, which no one accuſtomed to attend to the Phenomenon of the Ebullition of Water can miſtake for aerial Bubbles. After about two Ounces of this Fluid were evaporated, a *Ring* of *white*, and *apparently earthy Matter* was formed round the Inſide of the Flaſk in Contact with the Surface of the Water before Evaporation.

ration. The Evaporation was continued till about one-fourth of this Fluid was only left, and the Inſide of the Flaſk was now *covered with, ſeemingly, earthy matter*, and the remaining Fluid was poured out and found not perfectly tranſparent.

A little *muriatic Acid* was poured into the Flaſk from which the Fluid was juſt poured out; it excited a gentle *Efferveſcence*, and entirely *diſſolved* the Matter depoſited upon the Inſide of the Flaſk. A little of this Acid being added to a Tea-ſpoonful of the remaining Fluid made it quite tranſparent.

To two Ounces of this Fluid left unevaporated were added about an Ounce of *Lime-Water*, which inſtantly occaſioned a *pearly coloured Mixture*, that on ſtanding depoſited a *white Sediment*. To an Ounce of this Fluid alſo, was added ſome tranſparent Solution of fixed vegetable Alkali, which Mixture was *clear* and *without Sediment* after ſtanding.

This filtered Solution both before Evaporation, and after three-fourths of it were exhaled, formed an *uniform Mixture with Soap*.

Obſervations. This Experiment afforded me great Pleaſure;—to my Apprehenſion it ſhewed that the Conjecture made, p. 270, and 285 to 289, was in general true;—for the calcareous Earth was diſſolved in ſimple Water (*i*);—this Solution

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(*i*) If I am not miſtaken, Dr. *Black* uſed to relate in his chymical Lectures ſome Years ago, that he ſuſpended a Piece on the Addition of Lime-Water was firſt *muddy*, and then depoſited *a white Sediment*, which was a Compound formed by the Union of the Quicklime in the Lime-Water and the Gas united with the Compound of Gas and Quicklime in the Solution;—after evaporating this Solution to one-fourth of its Bulk it turned rather muddy, and depoſited a *Sediment*, as before Evaporation, on Mixture with Lime-Water;—during boiling, for a ſhort Time only, it extricated Bubbles of Vapour, and as the Evaporation proceeded *calcareous Earth* was *precipitated* from the Water.

Therefore, the preſent Opinion that a Spring-Water is combined with Gas, although it form a *milky* Mixture with *Lime Water* and *depoſit Sediment* on ſtanding, is not always true; becauſe Lime-Water added to Fountain-Water containing calcareous Earth in Solution attracts Gas from this Subſtance, which occaſions firſt *Muddineſs*, and, on ſtanding, a *Depoſition of Matter compoſed of Gas and Quicklime.* This Appearance, together with others ariſing from this Cauſe, which will now be readily comprehended, were obſerved Exper. II. p. 175, alſo p. 245 to 251, 265 and 280.

Having attempted to diſcover the Quantity of Gas contained in a given Quantity of Buxton

of Chalk in Water, and after ſome Time found it diminiſhed; from which he inferred, that Water diſſolves calcareous Earth.

and ſome other Waters, and its Mode of Combination, as propoſed p. 245; to which I was led, after ſhewing the permanent Vapours ſeparable by Heat from Buxton and other Spring-Waters; I remark, in Conſequence of the Inſtruction received by Experiments XVIII. to XXIX.

1. That the preſent generally prevailing Principle, the Solution of calcareous Earth in Water by Means of Gas, employed to explain the Depoſition of calcareous Earth from Fountain-Water on expoſing them to Heat, does not obtain with *Buxton*, *Matlock*, and the *common cold Springs* examined; nor does it explain juſtly the petrifying Quality of many cold Springs. For theſe Spring-Waters do not contain any Gas, excepting as one of the ſimple Subſtances neceſſary to the Conſtitution of the calcareous Earth diſſolved in theſe Waters; nor ſeparate any of this permanent Vapour during Evaporation, ſee Exper. XXVIII. p. 280; nor, ſuppoſing the Gas demonſtrated to be ſeparated from theſe Waters, ſee Exper. XXI. p. 245. to be combined with the ſimple Water and not with any Subſtance with which it is impregnated, is the Quantity ſuch as can be thought to be the efficient Cauſe of the Effects above-mentioned.

The obvious Occaſion of the Depoſition of Earth during Evaporation is the Loſs by Exhalation of Part of the ſimple Water, in Conſequence of which the remaining Water contains more Earth than it can diſſolve. See Exper. XXVIII. p. 280.

The efficient Cauſe of the petrifying Quality, or ſpontaneous Depoſition of calcareous Earth from the Springs here examined, has not been diſcovered by any Obſervations or Experiments. This Quality of certain Springs has been noticed by natural Hiſtorians and Poets (*k*) in ancient Times, and always regarded as a wonderful Phenomenon of Nature. After it was diſcovered, that a ſaturated Solution of Gas in Water contained a pretty large Proportion of calcareous Earth, and depoſited it upon Expoſure to the Atmoſphere, an adequate Cauſe was ſuppoſed to be found of this ſpontaneous Depoſition of calcareous Earth. Dr. Prieſtley, however, relates (Exp. and Obſ. Vol. V.), that he could not ſeparate Gas from a petrifying Spring, as he previouſly expected.

I have conceived the petrifying Quality of Springs to depend merely upon the Attraction between the minute Particles of calcareous Earth ſuſpended in the Water and the Surface of the Ground, or Subſtances immerſed therein, either becauſe the Menſtruum was more than ſaturated with this and other Subſtances, or becauſe the Time neceſſary for the Combination between

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(*k*) "Flumen habent Cicones, quod potum ſaxea reddit
" Viſcera, quod tactis inducit marmora rebus.

Ovid. Lib. xv. Fab. 5.

Water and this Subſtance to take Place was not allowed, from the Circumſtances of the Expoſure of calcareous Earth to the Action of Water before the Spring burſt through the Surface of the Earth. For although theſe petrifying Waters be as clear as any other Spring-Waters, and Tranſparency be one of the uſual Signs of Solution, yet it ſeems not improbable, that a Solid may be divided into Parts ſo minute as very little to diſturb the Tranſparency of the Water, when ſuſpended in no great Abundance therein.

It has been obſerved by Dr. Fordyce, in his Lectures, that all the Fluids of living Animals are petrifying Waters; and although they do not depoſit Earth upon *living* Veſſels, yet, whenever any extraneous or *dead* Matter is introduced or produced, this Earth is depoſited, and forms ſtony Concretions. Unleſs I am much miſtaken, petrifying Springs only depoſit calcareous Earth upon *dead* Matter; for I have obſerved, that various Species of Plants, as the Water-Parſnip, &c. grow in the petrifying Springs of Matlock, in the Channel that conveys them, expoſed to the Air, ſome Diſtance from their Source, without the ſmalleſt Incruſtation being formed upon them: whereas, *dead* animal and vegetable Matter, and foſſil Subſtances, become covered with calcareous Earth in the Space of a few Weeks, in the very Parts of the Springs where Plants live and thrive as in common Springs that do not poſſeſs the

Properties of petrifying. Some Species of Plants, however, as well as certain Parts of living Animals, as the Teeth, become incruſtated; for Moſs petrifies, although ſlowly, while growing in theſe Springs.

2. That it is extremely improbable, that calcareous Earth is diſſolved in Springs in general by Means of Gas; becauſe, before Water can perform the Solution ſpoken of, it muſt contain a large Quantity, or even be fully ſaturated with this Vapour; and, conſequently, every Spring that contains calcareous Earth diſſolved by Means of Gas ſhould be acidulous; depoſit this Earth, and loſe its acidulous Taſte, by mere Expoſure to the open Air; for, under this Circumſtance, a great Part of the Menſtruum eſcapes; and ſuch a Spring, ſhould precipitate this Earth more abundantly and ſpeedily by Expoſure to Heat, than happens from mere Evaporation of Water. But, Springs poſſeſſing theſe Properties are exceedingly rare; yet there are few Fountain-Waters that do not precipitate calcareous Earth during boiling; eſpecially thoſe flowing from Lime-Stone Beds, which are well known to have the Quality of incruſtating Veſſels in which they are boiled. Moreover, Brooks or Rivulets formed by many Springs containing Lime-Stone depoſit copiouſly calcareous Earth during boiling, and in which Fiſhes live in Health, and breed abundantly; but theſe Animals ſoon die

when put into Water impregnated with Gas, as Dr. Prieſtley has found.—See Exper. and Obſerv. Vol. II. p. 231.

3. That when calcareous Earth is contained in Water by Means of Gas, it is not *diſſolved* by this Subſtance; becauſe, as Dr. Fordyce has ſhewn, in his Chymical Lectures, the Gas is not altered by the calcareous Earth; it taſtes as acid with this Earth as without it, and the Water remains as perfectly ſaturated as before the Addition of calcareous Earth. Moreover, upon mere Expoſure to the Air of the Atmoſphere, of a temperate Heat, this Earth is depoſited; ſo that although a very ſmall Quantity of it may form a tranſparent Mixture with this Water ſaturated with Gas, it is rather *ſuſpended* in the *viſcid Fluid* produced by Gas diſſolved in Water, than by a *Solution* of Earth in this permanent Vapour.

Further, it is now generally believed, that the Iron in chalybeate Springs is *diſſolved* by Means of Gas; becauſe, when they are expoſed to the Atmoſphere, the Iron is depoſited in a calciform State; by Evaporation, a mere Calx of Iron is generally procured; and by mixing Iron Filings with a copious Solution of Gas in Water a Part of this Metal is diſſolved. But upon Examination of ſeveral chalybeate Springs that have the Property of decompoſing ſpontaneouſly, I have not met with one, which contained Gas ſenſible to the Taſte, or to the Teſt of Lime-Water in greater Quantity than in common Spring-Water. See p. 253.

Exper. XXX. A Wine Glaſs-full of a *chalybeate Spring* that decompoſed ſpontaneouſly, taſted very ſtrongly of Iron, had no acidulous Taſte, and contained no more Gas than common Spring-Water, was placed near the *Fire* of a common ſitting Room. Another ſimilar Glaſs-full of this Spring-Water was placed in a *cool* Part of the ſame Room.

As ſoon as the firſt of theſe Glaſſes became rather warm, it *ſparkled* with many Bubbles adhering to the Sides of it, was *turbid*, and of a *brown Colour*; but no Particles like Gas were ſeen to eſcape. The ſecond Glaſs was pretty *clear* for half an Hour; but after this Time was of a *browniſh* Colour, and pretty *tranſparent*.

Had the ſudden and abundant Depoſition in the firſt Glaſs depended upon the Eſcape of Gas, I apprehend, the Flight of this Subſtance muſt have been there *viſible*, if not during the ſlow and much leſs copious Depoſition in the other Glaſs.

Exper. XXXI. A Pint Florence Flaſk of this chalybeate Water was boiled a ſhort Time, and then ſet aſide for the decompoſed Matter to be depoſited; this being effected, the clear Water was poured off and filtered. Upon a Mixture of this filtered Liquor with Lime-Water, it appeared to contain *the ſame Quantity of Gas, although it was deprived of its metallic Impregnation, as a*

Parcel of this Spring-Water taken juſt before from its Source,

An eight Ounce Phial was perfectly filled with this chalybeate Water at the Spring-Head, and there cloſely corked, and afterwards kept inverted. Another Phial of the ſame Size was filled three-fourths full of this Water, then corked, and preſerved in an inverted Poſition. A third eight Ounce Phial was filled with this mineral Water, and ſet to ſtand in this Phial open to the Atmoſphere.

By ſtanding, all theſe three Phials of colourleſs Fluid became *ochry brown*, but remained clear; and they had all a ſmall Quantity of Sediment of the ſame Colour, but in greater Quantity in the Phial open to the Atmoſphere than in the other Bottles.

Hence it appears, that the Decompoſition of this mineral Spring was effected under Circumſtances that would prevent as well as ſuffer the Eſcape of Gas.

Thus then it is ſhown, that Iron is not diſſolved by Means of Gas; and that the ſpontaneous Decompoſition or Precipitation of mineral Waters containing Metals is not occaſioned by the Eſcape of this permanent Vapour. But if the Arguments we have produced in ſupport of theſe Poſitions ſhall be thought inſufficient, they will be placed beyond all Controverſy by the following Experiment, which may be conſidered as an *Inſtantia Crucis.*

Exper. XXXII. To a Jar containing a Pint of the above *mineral Spring* juſt taken from its Source was added ſuch a Quantity of tranſparent Solution of *fixed vegetable Alkali,* in a mild State; as was ſuppoſed ſufficient to decompoſe a Salt compoſed of Iron and vitriolic or other Acids. Upon adding this Alkali, the Water turned *greeniſh* and *turbid*; and on ſtanding depoſited a *copious brown Sediment* from a *colourleſs Fluid.* The clear Fluid was poured off and filtered.

To ſome of this *filtered Mixture* was added powdered Galls, which did not produce *any Colour* immediately or on ſtanding, excepting that of Infuſion of Galls in pure Water. But Galls of the ſame Parcel added to Water *freſh from the Spring* produced immediately a dark *purple Colour.*

Some of this *filtered Fluid* turned inſtantly *white* as Milk with Lime-Water; and on ſtanding depoſited a *large Quantity of white Sediment*; but the *freſh Water* and *Lime-Water* only turned pearly-coloured, and depoſited *a ſmall Quantity of Sediment.* With *Syrup of Violets* this *filtered Liquor* changed inſtantly to a *deep Graſs-green* Colour; but the *freſh Water* with this Syrup was only a very *pale Green,* or had a *greeniſh Hue* on ſtanding.

The *brown Sediment* left after pouring off the above Fluid that was filtered was ſaturated preciſely with *muriatic Acid,* and a Part of this Compound was diſſolved in Water. This Solution changed of a *purple Colour* on the Addition of powdered *Galls.*

The *chalybeate Spring* near the Bridge at Buxton was alſo ſubjected to the Experiment here related, and with the ſame Reſult; therefore, the ſame Inference is to be drawn from it as from this Experiment on the former mineral Spring.

Inference. As the metallic Matter was precipitated by Means of mild Alkali, although at the ſame Time a conſiderable additional Quantity of Gas was contained in the Water, to the Teſt of Lime-Water, it follows, that the Iron naturally contained in theſe Springs is not diſſolved therein by Means of Gas.

We therefore refer the ſpontaneous Decompoſition of chalybeate Waters, not to the Eſcape of Gas, as its Menſtruum, but to another efficient Cauſe demonſtrable by Experiment, *the Mixture of metallic Salts with conſiderable Quantities of Water* (*l*); provided there be no ſuperabundant Acid

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(*l*) "I never examined any mineral Water in which I "found the Metals combined with any other Subſtance but "vitriolic Acid; and I am certain many Authors have been "miſled by not knowing this Property of metallic Salts, viz. "that if we diſſolve them in a ſmall Proportion of Water, "or if there be ſuperfluous Acid, the Solution will remain "perfect when expoſed to the Air; but if the Acid be per"fectly ſaturated with the Metal, and the Proportion of "Water to the metallic Salt be very great, on Expoſure to "the Air it is decompoſed, the Metal being precipitated "in the Form of Calx, and the Acid being loſt. This may "eaſily be tried, by taking common green or blue Vitriol, "diſſolving

Acid mixed with theſe Salts. This Decompoſition is accelerated, and made more complete by Expoſure of the Water containing Iron to Heat, and the Atmoſphere.

In the above Experiment it is not improbable, that a ſmall Portion of the Calx of Iron precipitated by the Alkali added was ſuſpended in the Mixture; but yet this Calx, ſo ſuſpended, or not diſſolved, hath not perhaps the Power of coagulating Galls; and Mr. Lane, who diſcovered the Property of Water impregnated with Gas to ſtrike Colours with Galls after agitating it with Iron-Filings, did not find this Effect produced by Iron in a calciform State.

Moreover,

“ diſſolving an Ounce in three Ounces of Water by boiling,
“ letting them ſtand to cool, and filtering the Solution. If
“ this Solution be expoſed to the Air, it will remain per-
“ fect; but if we drop a Drop or two of it into a Wine
“ Glaſs-full of Water, in a few Minutes the Tranſparency
“ of the Water will begin to be diſturbed, and the Metal in
“ a ſhort Time will fall down in a red Powder, if it be Iron;
“ in a blue Powder, if it be Copper.”—See A *new Method of aſſaying Copper-Ores, by G. Fordyce, M. D. F. R. S.* Phil. Tranſ. Vol. LXX.

Mr. *Boyle* long ago noticed the ſpontaneous Decompoſition of Mixture of metallic Salts in a large Quantity of Water, eſpecially when expoſed to the Atmoſphere; but did not underſtand the Occaſion of this Effect. He ſays, “ The Precipitation was ſurpriſing from chalybeate Waters expoſed to the Air, but not ſo conſiderable in cloſe Veſſels, *as if the Air contained precipitating Salts.*”

Mr.

Moreover, if a ſmall Quantity of Acid of Vitriol be added to a chalybeate Spring that decompoſes on ſtanding, no Decompoſition enſues, and the Water, by this Means, preſerves its mineral Quality. This would ſcarcely happen, but for the ſame Reaſon that dilute metallic Solutions do not decompoſe with a ſmall Quantity of ſuperabundant Acid.

I next enquired what was *the Kind, and Quantity of ſolid Subſtances contained in Buxton-Water*.

By Means of Mixture, p. 173—231, we have diſcovered many of the *Kinds* and *Quantities* of ſome of the Subſtances contained in a certain Quantity of Water; but the *Kinds* and *Proportions* of ſome Things cannot be determined by

Mr. *Rouelle* obſerves, that Solutions of Mercury in nitrous Acid ſhould contain ſuperabundant Acid; becauſe when perfectly ſaturated, they form a Precipitate with any Kind of Water. Alſo, metallic Salts of all Kinds are, ſtrictly ſpeaking, capable of Decompoſition by Water alone. See *A Dictionary of Chymiſtry*, 8vo. Vol. III. 1777.

Biſmuth, a ſemi-metal, diſſolved in nitrous Acid without any ſuperabundant Acid, may be precipitated by Solution in a large Quantity of Water. The Subſtance thus precipitated by Water is *Magiſtery of Biſmuth*.—*Dictionary of Chymiſtry*, Vol. I. 1777.

Although ſeveral Chymiſts may have known the Property, that metallic Salts are capable of Decompoſition by Mixture with a ſufficient Quantity of pure Water, yet, I believe, Dr. Fordyce is the only Philoſpher who has made Uſe of this Fact to explain the ſpontaneous Decompoſition of chalybeate Springs.

Mixture; therefore we have recourſe to the Means of *Heat*.

Exper. XXXIII. I cut off the Necks with Part of the Shoulders of two large Florentine Flaſks, and aſcertained the Weight of each by Means of a fine Balance that had its Equilibrium deſtroyed by one-ſixteenth of a Grain.

Theſe Flaſks were filled rather more than three-fourths full of *Buxtòn tepid Water*: One was found to contain one Pound twelve Ounces and a half, Avoirdupois; and the other two Pounds one Ounce and a half.

This done, the Flaſks were placed in a Sand-heat of 150° to 180°; by which Means, in the Space of five Days, the whole of the Water was evaporated. In order to prevent the Introduction of any extraneous Matter during the Evaporation, the Mouths of the Flaſks were covered with Pieces of open Gauſe.

After the Evaporation of the Water the Flaſks had a Sediment adhering to the Inſides and Bottom of them in every Part where the Water had been in Contact with the Flaſks; and the larger Flaſk had *increaſed in Weight four Grains*, and the ſmaller one *three Grains and a half*.

About the *Middle* of the Inſide of the Flaſks, Sediment adhered more copiouſly than in the other Parts. Upon examining this Part of the Sediment with the naked Eye it appeared to conſiſt of *exceedingly ſmall Needle-like Cryſtals* of a blue

Colour; which, viewed through a magnifying Glaſs, appeared *tranſparent* and *colourleſs*, and of the *Figure of Cryſtals of Nitre and Glauber's Salt.*

As much of the Sediments in the Flaſks were waſhed off as poſſible, with a ſmall Quantity of boiling hot diſtilled Snow-Water. Theſe were mixed together, and filtered through Paper previouſly waſhed by diſtilled Water filtered through it.

This *filtered Liquor* was colourleſs, and a ſmall Portion of it did not alter the blue Colour of Violets; it taſted like Solution of Sea Salt, and a Part of it with Solution of Silver turned immediately pearly-coloured.

A ſmall Quantity of this boiling diſtilled Water was poured upon the Filter, and this *ſecond filtered Fluid* had an extremely ſlight Taſte of Sea Salt; and Solution of Lead with ſuperabundant Acid, as well as tranſparent Solution of Alkali were rendered turbid by it.

A ſmall Quantity of boiling hot diſtilled Water was poured a third Time upon the Filter. This *third* filtered Water was without Taſte, but was turbid like the laſt filtered Fluid with Solution of Lead, and with Alkali.

None of theſe filtered Fliuds produced Colour with Galls, or phlogiſticated Alkali.

The *Matter left upon the Filter* efferveſced and was diſſolved by muriatic and vitriolic Acids, with which it formed muriatic and vitriolic Selenites.

nites. The Solution of vitriolic Selenites with powdered Galls did not ſtrike any Colour, but upon adding Solution of Alkali to this Solution and Galls, a blackiſh and purple Colour enſued.

A Matter adhered ſo obſtinately to the Sides of the Flaſks that it could not be waſhed off by boiling Water repeatedly applied, nor by muriatic Acid to which it was expoſed for ſeveral Days; but it was removed by Solution of Alkali pretty readily.

Deduction. By thus evaporating Buxton-Water we learn that there is *no Acid or Alkali* contained in Buxton-Water;—that of the *neutral Salts* it contains only one, namely, *Sea-Salt*;—that of the *earthy Salts* there is only *vitriolic Selenites* and *calcareous Earth*;—and that it is not impregnated with any metallic Salt or Earth.

We find that the Proportion of *ſolid Matter* procured by Evaporation is about ſixteen Grains to a Gallon of Water, or one Grain to eight Ounces of Water, or $\frac{1}{3340}$ of the Weight of the Water; and that this conſiſts of three Things, *Sea-Salt*, *vitriolic Selenites*, and *calcareous Earth*.

This Experiment manifeſts, as exactly as can be contrived, the Proportion of ſolid Matters to the Water; it alſo ſhows that the Subſtances of which they are compoſed are the ſame as I have uſually found in common *hard* Waters. From the Smallneſs of the Quantity of theſe Subſtances Buxton-Water is entitled to be ranked *among the* *pureſt, if it be not the pureſt of hard Waters*, and, perhaps, *among thoſe next in Purity to Snow and Rain-Water*; for it contains about ſix Times as much Sediment and of the ſame Kinds of ſolid Subſtances as Rain-Water, and nine Times as much ſolid Matters and of the ſame Kinds as Snow-Water (*m*).

Buxton-

(*m*) The learned Dr. *Heberden* evaporated many *Pump-Waters* to Dryneſs, and they all incruſtated the Veſſels, and left at leaſt ten Grains of Sediment, after each Quart was exhaled away.

Margraaf found all the Wells in and about Berlin impregnated with *calcareous Earth*; in 3600 Ounces, or 100 Quarts of 36 Ounces each, they contained one Ounce two Drachms to four Drachms and 27 Grains of this Subſtance. In this Quantity of Water, moſt of them held of *vitriolic Gypſum*, from three Drachms and a half to four Grains: Alſo, moſt of them contained *Sea-Salt*, from three Drachms to 30 Grains: And ſeveral contained *Nitre*, from one Ounce and one Drachm, to eight or ten Grains. In other Waters, in the above Quantity of them, the following Subſtances were found: two Springs were impregnated with *Magneſia Glauber-Salts*, in Quantity from 30 Grains, to a few Grains only. Three Wells held in Solution four Drachms to 30 Grains of *nitrous and muriatic Selenites*. Two Springs contained 30 Grains of *alkaline Lixivium*; and in another, a ſmall Quantity of this Subſtance. Moreover, 100 Quarts of *Snow-Water* afforded one Drachm of *calcareous Earth*, a few Grains of *muriatic Acid*, and a *nitrous Subſtance*, And this Quantity of *Rain-Water* left a Drachm of *calcareous Earth*, and a few Grains of *nitrous Acid* and *common Salt*. 100 Gra

Dr. *Hales* and Dr. *Rutty* found Sediment in rather greater Quantity from Rain and Snow-Water than the ingenious and accurate Chymiſt of Berlin.

Buxton-Water has been repeatedly evaporated to Dryneſs by ſeveral Perſons; from which Experiment we can only conclude, that the *Quantity* of ſolid Matter impregnating it is leſs than that of Springs in general: but nothing can be ſatisfactorily deduced from it with Regard to the *Qualities* of this Sediment. We muſt except from this Stricture this Experiment made by the following Gentlemen.

Dr.

River-Water contains nearly as great a Weight of Sea-Salt, namely, $\frac{1}{4000}$ Part of its Bulk, as Buxton-Water does of the whole of its ſolid Subſtances.

Excepting Buxton-Water, the pureſt Spring-Water, that has been hitherto examined, is Briſtol-Water; which, according to Dr. *Hales*, contains in 34 cubic Inches, four Grains of Sediment, or as 1 to 2222; and according to Dr. *Higgins*'s Analyſis, this Water contains one Dwt. nine Grains in a Wincheſter Gallon.

Matlock-Water has been reported to contain 40 Grains of Sediment in a Gallon of Water, which is called *Nitre, alkaline Earth*, and Sea-Salt.

Hippocrates entertained very erroneous Notions of the Nature of Snow-Water, and Water that had been frozen, although he underſtood well the Properties of Rain-Water. He ſays, Rain-Water is the lighteſt, ſweeteſt or moſt inſipid, thinneſt, and moſt limpid of all Waters; for the Sun only takes up what is the thinneſt and lighteſt, as in the Caſe of Water evaporated from the Sea; but all Snow and Ice-Water is pernicious, for Water after being concreted never returns to its former State, being thereby deprived of its more volatile Parts, as may be proved in the following Manner: If you take a Veſſel of Water, and expoſe it to the Air

to

Dr. A. Hunter ſays, "I ordered four Gallons of Buxton-Water to be carefully evaporated over a gentle Fire, and obtained five Scruples of a mixt Compoſition, whereof one Drachm was a light blue-coloured Earth, and the remaining two Scruples, by all the Trials I could make upon them, appeared to conſiſt of a native alkaline nitrous Salt, with about an equal Portion of marine Salt." See this Author's uſeful *Treatiſe on Buxton-Waters.*

to congeal, and afterwards bring it into a warm Place to thaw, you will find the Water leſs in Bulk; hence we know, that what is thin and light has eſcaped, not what is thick and heavy. On this and other Accounts, Snow and Ice-Water are the worſt Kinds of Water.—See *Hippocrates de Aëre, Aquis & Locis.*

Pliny, perhaps upon the Authority of Hippocrates, alſo alledges, that Snow and Ice-Water are inſalubrious, becauſe the lighteſt Part is evaporated; and yet he recommends, upon the ſame Authority, boiling, Filtration, and extinguiſhing red hot Iron in Water, in order to make it leſs unwholeſome. *Pliny* alſo propoſes, that the Miſchief of Snow-Water may be avoided, and the agreeable Quality, its Coldneſs, preſerved, by putting a Veſſel of Water into a Bag of Snow; this, he ſays, was the Invention of Nero,—"Ita Voluptas Frigoris ſine Vitiis Nivis."

The Opinion that Snow contains a conſiderable Quantity of Nitre, on which its Property of fertilizing the Earth depends; and that it is an impure and unwholeſome Water, prevails even at this Day, although the cleareſt Proofs have been given by Dr. *Rutty* and Mr. *Margraaf*, that it is nearly as pure as diſtilled water.

Dr. *Percival,* Phil. Tranſ. Vol. LXII. p. 455, ſays, " the Water of St. Anne's Well was found by Analyſis, to contain calcareous Earth, foſſil Alkali, and Sea-Salt:—That a Gallon of the Water, when evaporated, yields only twenty-three or twenty-four Grains of Sediment." This Account was communicated to this Author by the worthy Phyſician who at preſent attends at Buxton.

Dr. *Higgins* reported, in a Hand-Bill, dated June 9, 1782, and alſo in the News-Papers, that *Buxton-Water* afforded " in a Wincheſter Gallon $17\frac{16}{20}$ Grains of Sediment; of which $11\frac{1}{2}$ Grains were calcareous Earth combined with acidulous Gas, $1\frac{1}{2}$ Grain Selenite, $3\frac{1}{2}$ Grains Sea-Salt, $1\frac{1}{4}$ Grain marine Salt of Magneſia, and $\frac{1}{20}$ Grain was Iron combined with acidulous Gas, excluſive of the Quantity contained in calcareous Earth, in the Heat of boiling Water."

It was neceſſary to procure a larger Quantity of the above Sediment, *in order to determine more certainly the Kind, and Quantity of each of the Subſtances of which it was compoſed,* on which Account I made the following Experiment.

Exper. XXXIV. Three Gallons of Buxton-Water were evaporated to Dryneſs in a gentle Heat, by exhaling three Quarts of it at a Time in a Glaſs Retort, that had its Neck and Shoulder broke off, to about *four Ounces*; and then evaporating theſe ſmall Quantities, to which the three Quarts were reduced, in one of the Flaſks employed in the laſt Experiment, to about *one Ounce*; when there appeared to be, upon cooling, *a few ſmall Cryſtals*, but not ſufficiently large or diſtinct to denote any particular Salt; and this remaining Fluid *taſted ſtrongly of Sea-Salt.* The Evaporation was then continued to Dryneſs, and the *Sediment*, collected from the Retort and from the Flaſk, *was found to weigh forty-five Grains.* The Sediment in the Retort had very little or no Taſte, but that in the Flaſk was ſaline.

The whole Sediment was mixt with half an Ounce of diſtilled Water boiling hot, and then filtered. This filtered Fluid taſted Salt. Another half Ounce of this Water, boiling hot, was poured upon the Filter, but this ſecond filtered Fluid had only a very ſlight ſaline Taſte. A little of the *firſt* half Ounce Meaſure of filtered Fluid had not its Tranſparency diſturbed on the Addition of Solution of *Alkali*; and had no Colour produced on the Addition of *Galls* or *phlogiſticated Alkali.* Theſe two half Ounce Meaſures of filtered Fluid evaporated ſlowly to Dryneſs together afforded *five and a half Grains of Cryſtals*, approaching to a cubical Form, when viewed with a Magnifier; which, from their Figure, Taſte, forming when diſſolved in Water a pearly Fluid on adding *Solution of Silver* with ſuperabundant nitrous Acid, and ſcarcely a Diſturbance of Tranſparency with Solution of *Alkali* were judged to be principally *Sea-Salt.*

Three Ounces of boiling hot diſtilled Water were ſucceſſively poured on the Sediment upon the Filter, and formed Solutions of a ſomewhat ſaline diſagreeable Taſte; but the *fourth* and *fifth* Ounce of diſtilled Water ſucceſſively poured upon Sediment of this filtered Water had no particular Taſte, excepting that it was rather earthy. A little tranſparent Solution of *fixed Alkali* being poured upon a ſmall Portion of the laſt Ounce of filtered Fluid, after it had ſtood ſome Time, occaſioned a very ſlight Diſturbance in its Tranſparency, but with the four other Ounces a very evident Decompoſition immediately.

Theſe five Ounces of filtered Solution afforded upon Evaporation about *ſeven Grains and a half* of a ſomewhat Needle-like Group of Cryſtals, that had little Solubility in the Mouth, had a bitter nauſeous Taſte, and hence were pronounced to be *vitriolic Selenites.*

The Matter upon the Filter was dried and weighed *thirty-one and a half Grains:* It was white, light, very ſmooth upon the Tongue, and without Taſte. A ſmall Quantity of this Subſtance formed vitriolic Selenites with vitriolic Acid, and muriatic Selenites with marine Acid.

Three-fourths of this Matter left upon the Filter was combined with vitriolic Acid, and after Dilution with Water was filtered and afforded a ſlightly ſaline, rather nauſeous Fluid, that with *Galls* and *phlogiſticated Alkali* did not ſtrike a Colour; and being evaporated to Dryneſs left a very ſmall Quantity, two or three Grains, of Sediment that had only a ſomewhat bitter Taſte, and required a large Quantity of Water to diſſolve it.

Therefore, this Matter left upon the Filter was concluded to be thirty-one Grains and a half of calcareous Earth.

Remarks. The above are the Kinds and Quantities of Subſtances contained in the Quantity of Buxton-Water uſed in the above Experiment, that are manifeſted by Evaporation, Solution, Decompoſition, &c. Our Concluſion, however, ſhould be made always with this Condition, that the Subſtances ſhewn by this Experiment are in ſuch Quantity and of ſuch a Kind in the Waters as thoſe ſolid Matters that exiſt in the Waters, provided they be not altered in their Quality, in Conſequence of the Operations in this Experiment; by which it is poſſible to decompoſe earthy Salts, alter Subſtances ſo as to produce Magneſia from calcareous Earth, Earth from Alkali, &c.

Margraaf obſerves that the Quantity of Earth or Sediment is various according to the *Heat* employed; for when the Water is evaporated by boiling briſkly, there is more Earth than when it is boiled ſlowly; hence the Quantity may be different on different Trials. Moreover that we only procure by *one Evaporation* of Water to Dryneſs *Part* of its ſolid Matters; for Water after being diſtilled 40 Times ſtill left Sediment upon further Diſtillation.

It is therefore not a Matter of Wonder that the ſame or different Perſons who have aſſayed Buxton and other Springs, ſhould have found *different Quantities*, and ſometimes *different Kinds* of Matter left after Evaporation, although the Experiments were performed with equal Accuracy, and, perhaps, in the ſame Manner; and although the Water does not vary at different Times either in the Quantity or Quality of its Impregnations. Suppoſing, however, the Subſtances ſhewn by *any* of the above cited Experiments to be the *Sort* and *Quantity* of ſolid Subſtances contained in Buxton-Water, we may juſtly infer, *that this Spring has no peculiar Power of removing or preventing Diſeaſes of which the ſolid Matter it contains are the Occaſion, according to any known Properties of them in the Quantity neceſſarily exhibited when this Water is applied.*

It has been well known that Buxton and Matlock-Waters, like Springs flowing from Lime-Stone Beds in general, incruſtate the Kitchen Utenſils in which they are boiled. I accordingly availed myſelf of the Opportunity of procuring a large Quantity of Sediment depoſited during boiling from theſe Waters by beating off the ſtony Cruſt formed on the Inſide of Tea Kettles employed at Buxton and Matlock, for the Purpoſe of ſatisfying myſelf further concerning the Properties of the ſolid Matters contained in theſe Waters that are procured by Evaporation, or precipitated by a boiling Heat.

Exper. XXXV. The earthy Matter depoſited by boiling *Buxton-Water*, and found incruſtating the Tea-Kettles, examined in this Experiment, was of a *gray* or *light brown Colour*, in *hard Cakes*, *gritty* to the Palate, *inſipid*, and of a *cloſe Texture.*

The Matter found adhering to the Sides of Tea-Kettles after boiling *Matlock-Water*, and uſed in this Experiment, was of a *Snow-white Colour*, *ſoft*, and *ſmooth*, *had no Taſte*, was much *lighter* than the former, and *readily crumbled to Powder* under the Fingers. There is, I am told, this Difference of Colour and Texture uniformly between Buxton and Matlock-Water, with Reſpect to the Sediment depoſited by boiling. And I am alſo informed, that the calcareous Matter incruſtating Veſſels in which Water in general is boiled, is never like that from Matlock-Water in Colour and Texture.

Two Ounces of each of the above Sediments reduced to Powder were ſeparately expoſed in a Sand-heat for ſeveral Days, with four Ounces of *diſtilled* Water, and then filtered.

This filtered Fluid had only an earthy Taſte. Galls, and phlogiſticated Alkali added to a ſmall Portion of it, did not ſtrike any purple or black Colour, or produce any coloured Precipitation. With Solution of Lead in nitrous Acid with redundant Acid, and with fixed Alkali, it was rendered turbid, and on ſtanding, depoſited a Sediment; being evaporated to Dryneſs, it afforded a Grain and a half of Sediment from each Ounce of evaporated Fluid. This Sediment had a bitter Taſte: a Part of it only diſſolved in mineral Acids.

A Part of this Matter incruſtating Veſſels is ſoluble in muriatic Acid, with which it forms muriatic Selenites; and the Part not diſſoluble by this Acid appears to be vitriolic Selenites.

Powder of Galls added to recent Solution of this Sediment in vitriolic Acid diluted with Water, either produced a purple, black, or blue Colour, alone, or on the Addition of fixed Alkali to the Galls and Solution.

Therefore, the *Matter depoſited by boiling Buxton and Matlock-Water for Infuſions of Tea does not contain any neutral or metallic Salts, but only calcareous Earth and vitriolic Selenites.*

It has been ſhewn, p. 282, that this Depoſition does not ariſe from Gas extricated, which was the Menſtruum of calcareous Earth in the Water, but from the Evaporation of the Water, by which Part of the Solvent of this Earth is carried off, and the remaining Fluid having more Subſtances than it can retain in Solution, calcareous Earth is precipitated, and alſo vitriolic Selenites; both of which Subſtances are ſoluble only in a very ſmall Quantity in Water: But the other Matters, being more ſoluble in Water, and contained therein in ſmaller Quantity, by the mere Evaporation from Water boiled for Kitchen Uſes, are rarely or never precipitated, and conſequently not found making a Part of the earthy

Coat of the Inſide of Veſſels uſed to boil Water (*n*).

The three laſt Experiments were as deciſive as any I could employ to diſcover the Subſtances left by Evaporation, and the Quantity of each of theſe Subſtances; but becauſe diluted Solutions of neutral, earthy, and metallic Salts are apt to decompoſe, and thereby loſe their Acid by Evaporation, it was next enquired, *whether any Acid was carried off by exhaling Water to Dryneſs.*

Exper.

(*n*) It has been mentioned, p. 310, that *Dr. Higgins* found the Subſtances here related, in a different Proportion from that found in our Experiments, but yet not ſuch a Difference as is at all to be wondered at, for Reaſons before given; and, for the ſame Reaſons, it is very poſſible there may be ſome Difference in the *Kind,* as well as *Quantity,* of Subſtances diſcovered on Evaporation; accordingly, this profeſſed and celebrated Chymiſt ſays, A Gallon of Buxton-Water left upon Evaporation *a Grain and a half of marine Salt of Magneſia,* which might be occaſioned by the Converſion of Part of the Alkali of the Sea-Salt into Magneſia during the Experiment, as happens upon other Occaſions; and that a Gallon of this Water contains $\frac{1}{20}$ *of a Grain of Iron combined with acidulous Gas.* I can account in no other Way for this laſt Subſtance than by ſuppoſing that the Specimen examined by this Gentleman, contained a minute Portion of this Metal *accidentally* ſuſpended in the Water, which, if taken from the Bath, might readily happen, becauſe of the Iron Rails within the Water of the Bath. As to its being combined with Gas, the probable Miſtake in this Reſpect, has been fully ſhewn in various Parts of this Work. It would be extraordinary indeed, that in many deciſive Experiments

Exper. XXXVI. I added ſuch a Quantity of *pure fixed Alkali* to *four Quarts of Buxton-Water* as was more than ſufficient to decompoſe any earthy or metallic Salts diſſolved therein. After allowing this Mixture to ſtand a ſufficient Time, the clear Water was decanted and filtered; this filtered Fluid was diſtilled in a Glaſs Retort in a *gentle Heat*, and a Piece of Paper ſtained with *Archill* was fixed to the Mouth of the Retort ſo as to be expoſed to the Vapour paſſing into the Receiver. During the Evaporation in this Manner to Dryneſs the Paper only became of a *deeper purple Colour* than before, and the Matter left after Evaporation, conſiſted of three Things, *Sea-Salt*, *vitriolated Tartar*, and *fixed Alkali*.

As nitrous Acid combined with Alkali or Earth has been ſaid to be contained in theſe Waters, I ſhall relate, in particular, that Paper dipped into a Solution of this Sediment, and after drying ex-

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periments which I have related, theſe two Subſtances ſhould not have been met with, had they exiſted naturally in the Water; in particular, ſee Exper. XI, XII, XIII, XIV. XXXIII, XXXIV, and XXXV.; and becauſe we ſhould expect the Heat of boiling Water to decompoſe muriatic Salt of Magneſia, thus depoſit its Earth, and detach its Acid, in Exper. XXXV. Whether theſe Subſtances do, or do not exiſt in Buxton-Water, is of no Conſequence in the Quantity mentioned, with Reſpect to the Practice of Phyſick: I recommend, however, the Reader to conſider and determine for himſelf whether the Experiments here made were adequate to the Detection of theſe Subſtances, had they there exiſted.

poſed to the Flame of a Candle, did not burn like a Match made by immerſing Paper into a Solution of Salts with nitrous Acid exiſting as an Element in their Compoſition.

I was not able to determine, with any Preciſion, the Quantity of each of theſe Subſtances, on Account of the Mixture of Alkali with them, which could not readily be ſeparated from the neutral Salts; but by Eſtimation it could not much, if at all, exceed the Quantity of neutral and earthy Salt, to wit, *Sea-Salt* and *vitriolic Selenites* formed upon Evaporation in Exper. XXXIV. p. 310.

In this Experiment we ſhould expect to find, upon Evaporation, any Acid combined naturally with Earth or Metal in the Water united to the Alkali added to the Water, forming therewith a neutral Salt according to the Nature of the Acid, as well as the neutral Salts of this Spring. The vitriolated Tartar was formed by the vitriolic Acid of the Selenites decompoſed by the Alkali added to the Water, and the Sea-Salt might be this neutral Salt impregnating naturally theſe Waters, according to Exper. XXXIV: but conſidering the *Quantity of the neutral Salts* here left upon Evaporation, it is not probable that any earthy or metallic Salt was decompoſed by the Alkali, and thereby formed neutral Salts, excepting the vitriolic Selenites; and as no *Redneſs* of Colour was produced of the Paper expoſed to the Vapour ariſing from this Mixture, it ſeems to be proved by this Experiment, that *Buxton-Water does not contain any earthy or metallic Salts, excepting vitriolic Gypſum.*

Exper. XXXVII. It did not appear probable, that theſe tepid Waters contained any *phlogiſtic Matter* becauſe they had *no Smell*, p. 154, and *did not tarniſh Silver*, p. 229. But to ſatisfy myſelf concerning this Fact, I fixed a Shred of writing Paper that had been dipped in a Solution of *Sugar of Lead* in Water and afterwards dried, in the preceding Experiment ſo as to be expoſed to the Vapour of the Water during Diſtillation, as well as the Piece of Paper dyed with *Archill.*

This Paper, which had been immerſed in Solution of *Saccharum Saturni*, neither before nor during the Evaporation was at all *coloured* until the Luting, compoſed of vegetable and animal Mucilage, was ſenſibly burnt by the Degree of Heat to which it was expoſed in this Experiment, at which Time this Paper was of an *Orange-brown*, and afterwards of a *blackiſh or Lead-Colour.*

Phlogiſton ariſing from any Subſtance is frequently announced by the brown or blackiſh Colour produced of Paper that has been dipped in Solution of the Sugar of Lead, as above-mentioned; by which Means, as I have already obſerved, I have diſcovered the Eſcape of phlogiſtic Matter both before and during the Putrefaction of animal Matter, as well as by immerſing poliſhed Silver in the Maſs to be putrefied.

In the above Experiment, the *Colour was not apparently produced by the Separation of Phlogiſton from Water, but from the luting during its Deſtruction by Heat.*

Concluſion of PART II.

I ſhall now cloſe the *Second Part* of this Work, in which, among other Things, we are inſtructed:

I. *By the immediate Application of Buxton-Water to the external Senſes and by Inſtruments*, p. 150 to 173, *that it does not contain any Impregnation evident to the external Senſes, excepting, in a very unuſual Form and Quantity, permanent Vapour, which is not Gas, any Vapour that has a Smell, or Air*; *or only a Part of it is this laſt Vapour*;—*that if it be impregnated with other Matters it contains a ſmaller Quantity of them than common Spring-Waters*;—*that its Heat exceeds that of the interior Part of the Earth and of ordinary Springs, which are of the Temperature of about* 48 *or* 50°, *inaſmuch as this Water is about* 81°; *and common Springs excite the Senſation of Cold, but Buxton-Water feels rather tepid.*

II. *By Means of* MIXTURE, p. 173 to 231, *that the tepid Water of Buxton does not contain any Acid, excepting Gas,* (*and that only according to a Teſt afterwards ſhewn to be perhaps erroneous*) *or any Alkali*;—*that it contains Acid of Vitriol and marine Acid combined probably either with Alkali or Quicklime, and Gas combined with Quicklime, or with*

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the Compound of Gas and Quicklime; alſo Quicklime united with another Acid beſides Gas;—that it does not contain Magneſia or metallic Salt;—it is impregnated with permanent Vapour, a Part of which may probably be Air: and it contains no phlogiſtic Subſtance.

III. *By Means of* Heat *it appears,* p. 231 to 321, *that this* tepid Water *contains about* $\frac{1}{64}$ *of its Bulk of permanent Vapour, or four Ounce Meaſures to four Ounce Meaſures and a half of permanent Vapour (meaſured when of the mean Heat, and under a moderate Preſſure of the Atmoſphere) in* 16 *Pints of Water, a Part of which Subſtance is Air: But the Kind of Vapour with which this* Air *is mixt was not evident, excepting that it was not Gas, or any phlogiſtic Vapour.*

—*That* Matlock-Water *contained, in the Quantity of ſixteen Pints, three Ounces and a half to four Ounce Meaſures of Vapour which was found to be* Air.

—*And that this Quantity of a* common Spring-Water *was impregnated with three Ounces and a half Meaſure of permanent Vapour that appeared to be Air.—That the Air in theſe two laſt Springs rather exceeded Air of the Atmoſphere in Purity.*

That the Subſtance which combined with Quicklime on the Addition of Lime-Water to Buxton, Matlock, and common Spring-Waters, and formed therewith a white Precipitation, was Gas; and, eſtimating the Quantity of this permanent Vapour by the

Quantity of Lime-Water that is ſaturated by a given Portion of this Subſtance in Spring-Water, BUXTON-WATER *contains about half the Quantity of Gas that is found in common Springs, and rather leſs than Matlock-Water and other petrifying Springs here examined; that judging of the Quantity of Gas in Springs by the Quantity of Gas that will ſaturate the Quicklime in a certain Bulk of Lime-Water, as it requires the Gas of fourteen Pints of Buxton-Water, and of about thirteen Pints of Matlock-Water to unite with the Quicklime of four Pints of Lime-Water, and eight Pints of the common Springs examined to unite with the whole of the Quicklime in four Pints of Lime-Water; and as four Meaſures of Gas are required to ſaturate the Quicklime in nine Meaſures of Lime-Water, it appeared that the above Quantities of theſe Springs contained four-ninths of four Pints, or about twenty-eight Ounce Meaſures of Gas: That it does not appear we can eſtimate the Quantity of Gas in Spring-Water by the Weight of the Sediment formed by the Union of the Quicklime of Lime-Water and the Gas of Spring-Water, when this permanent Vapour is only partially ſaturated, but that when the Gas is preciſely ſaturated it is eſtimated from the Weight of the Sediment, that ſeven Pints of Buxton-Water and four Pints of common Spring-Water contain each about four Ounce Meaſures or ſix Grains Weight of Gas; that the Quantity of this Gas obtained by decompoſing this Compound of Gas and Quicklime is four Ounces and three Quarters*

ters to five Ounces and three-fourths Meaſure of Gas from three Pints and a half of Buxton-Water, three Ounce Meaſures of this permanent Vapour from two Pints of Spring-Water, and three Ounce Meaſures of Gas from three Pints and a half of Matlock-Water, and one Pint of Lime-Water, when the Gas in theſe three Spring-Waters is preciſely ſaturated by Lime-Water; but when this permanent Vapour is not ſaturated, theſe Waters afforded ſeven Ounce Meaſures of Gas from each Pint of Lime-Water ſaturated. That the QUALITY *of the Gas in theſe Spring-Waters is the ſame, with Regard to Degree of Concentration conſidered as a Species of Acid, as this permanent Vapour extricated from calcareous Earth;—and that the Quantity of Gas may be known in a certain Quantity of Spring-Water by aſcertaining the Quantity of Lime-Water that will ſaturate this permanent Vapour in a determined Bulk of Water; for the Quality of Gas in Springs being the ſame as that obtained by Art, the Quantity required to ſaturate a Quantity of Lime-Water equal to that ſaturated by this permanent Vapour in a certain Quantity of Spring-Water is the Quantity of this Subſtance in that Quantity of Water.—That the Gas in theſe Spring-Waters cannot be ſeparated by the Heat of Boiling Water;—that the Concluſion is falſe, becauſe a Spring-Water contains Gas to the Teſt of Lime-Water, and depoſits calcareous Earth during Expoſure to Heat, this Earth is there diſſolved by Gas;—that the Water remaining after evaporating*

porating any Part of a given Bulk of Spring-Water contains the ſame Quantity and not more Gas than an equal Bulk of Water before Evaporation;—that the Gas in Buxton, Matlock, and the common Springs ſubjected to Examination contain Gas combined with Quicklime, or with the Compound of Gas and Quicklime, and not with ſimple or elementary Water, as hitherto ſuppoſed;—and that a Solution of calcareous Earth produced the ſame Appearances on the Addition of Lime-Water as the above Springs.—That IRON *and other Metals were not in general diſſolved by Gas in mineral Waters, but by an Acid; and that the ſpontaneous Decompoſition of chalybeate Waters might not, and actually does not, depend upon the Eſcape of Gas, but upon a different efficient Cauſe, namely,* DILUTION *of the metallic Salt with which theſe Springs are impregnated.—That the tepid Springs of Buxton afforded upon Evaporation* $\frac{1}{3840}$ *of their Weight, or ſixteen Grains of ſolid Matter in a Gallon of Water, which was Sea-Salt, vitriolic Selenites, and calcareous Earth; that the Quantity of each of theſe was about one Grain and three-fourths of Sea-Salt, two and an half Grains of vitriolic Selenites, and ten Grains and a half of calcareous Earth;—that the Cruſt formed on the Inſide of Tea-Kettles and other Veſſels, after boiling Buxton and Matlock-Water, is calcareous Earth and vitriolic Selenites;—that during boiling or Evaporation by a leſs than boiling Heat no Acid can be detected to be ſeparated, conſequently,*

ently, there is no Decompoſition by the Heat of boiling Water of any Kind of neutral, earthy, or metallic Salt;—and it was further proved, that this Water contains no Acid excepting Acid of Vitriol, muriatic Acid, and Gas combined with fixed foſſil Alkali and Quicklime;—and laſtly, that Buxton-Water does not contain any phlogiſtic Subſtance ſeparable by Heat and Evaporation.

As common Springs contain the ſame ſolid Subſtances diſcovered in Buxton-Water, and in much greater Quantity; and as, from the known Properties of theſe Subſtances, we have no Reaſon to expect any beneficial Effects from them in diſeaſed States in the Proportion in which they are contained in theſe Springs, the Conſideration of them may be neglected in Practice, and the peculiar medicinal Qualities of Buxton-Water muſt be ſought for on other Principles.

A Review of the preceding Hiſtory pointed out, that *this tepid Water* might be particularly powerful in curing Diſeaſes on three Grounds,

I. *On Account of its Purity* (o), *or ſmall Quantity of Impregnation*;

II. *From its Temperature*;

(o) Concerning the Effects of pure or elementary Water in the Cure of Diſeaſes, perhaps ſome Facts may be collected from Writings *on the Uſe of Snow-Water*, which is nearly as pure as diſtilled Water, and is not a hard Water, or has any Effects dependent upon Nitre, as has been ſuppoſed.

III. *In Conſequence of the permanent Vapour obſerved to eſcape ſpontaneouſly from Buxton-Water,* p. 152, 153, *and which is mixed with Air when ſeparated by Heat,* p. 238, 239.

The Hiſtory of the Properties of this permanent Vapour that ariſes ſpontaneouſly has been inveſtigated in order to diſcover whether it had any Effects, or what might be its Powers in diſeaſed States; and as the Experiments and Obſervations made with this View are numerous, and the Subject is new, copious, and intereſting, I have treated it diſtinctly in the *third Part* of this Work.

END OF VOL. I.